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GOLD, COPPER AND LEAD.

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IN

CHOTA NAGPORE

AND THE ADJACENT COUNTRY,

WITH

Map shewing the Geology of the Gold-Fields and the approximate boundaries of the areas taken up by the principal Prospecting and Mining Companies to October 31st, 1890.

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PREFACE.

THE present interest, if not excitement, in Calcutta and indeed throughout India, regarding the auriferousness of Chota Nagpore and the adjacent country, calls, we think, for some renewed and convenient account of what is actually known of the occurrence of gold in the districts of Western and South-West Bengal, as well as some rational and common-place discussion as to what such occurrence points to in the way of development.

It is easy enough to place before the reader what has long been known of this gold : for such knowledge is extant in many of the early publications of Calcutta, particularly in the Journal of the Asiatic Society of Bengal ; while these old records have been from time to time verified, or the reverse, during the progress of the Geological Survey of India, in the Memoirs, Records, and Manuals of which Department these explorations have been embodied, and finally sifted and epitomized, as far as this could be done up to the time, in Part III of the Manual of the Geology of India compiled by Mr. V. Ball, the maps of the Survey of India having at the same time been utilized as much as possible in the topographical delineation of the sites of auriferous tracts.

Much more difficult is it, however, and as yet even almost impossible, to discuss with any amount of surety the future of the development of what are presumed to be the brilliant potentialities of this so long latent field ; because by all the

evidence obtainable so far, the country in many respects is more obscure in its indications of the original sources of its gold, or much less evident as a region of ancient mining than any other gold tract in India.

The common and well-worn but favourite saying that such-and-such a country is a very likely-looking gold country because it resembles, or is assumed to resemble, other auriferous tracts in India and other parts of the world, is also of little value; the physical aspect, which is seldom really the same, having very little to do with the occurrence of gold, though the details of geological structure and mineral constitution are often very similar. To cite only a few prominent differences in auriferous tracts: there may be only gold washings in one case; there may be strong quartz reefs in the other with very little gold; or there may be very small quartz reefs with much gold; or the gold may be distributed throughout the country rock, but so sparsely as to be really only attributable to the sub-aerial denudation or degradation of these, year by year. Or, the quartz may be white and rusty in the reefs of one region, or blue and grey without any rustiness in another. Or, again, as in Southern India, there may be the actual ruins of ancient mines, concerning the workers in which, and the metal extracted, there is no tradition extant.

We have also thought that, now that the actual taking up of land by concession for the working of such gold and other metals has been carried on for some time, while the concomitant growth of companies, with their ever associated rage for speculation and even ruinous trafficking in the craving after fickle

fortune, has quieted down, the development may to some extent be steadied and furthered not only by a plain statement of the facts and their indications, but by such collation of the tracts and properties taken up or under negociations of tenure as we could obtain from the several companies engaged in the development. And to the attainment of these ends, we are bound to acknowledge the most open and courteous co-operation of all the Bengal Companies in affording us every information about their properties.

As a matter of fact, the first violent symptoms of gold fever have passed; and the time has come, as it inevitably must have done, for steady, systematic and honest exploitation. This, however, needs a guide; and for this, we now venture to put forward this little book, though it be after all merely a compilation of the explorations and views, so far as they are safe, of men who traversed a country the mineral conditions of which have as yet been only generally studied, because at their time the difficulties of travelling were far greater than they now are.

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GOLD, COPPER AND LEAD IN CHOTA NAGPORE.

PART I.—GOLD.

Introductory.

The most patent fact connected with the present attempt at auriferous development in Chota Nagpore and the adjacent country, is that gold has been known to exist for ages: gold was washed for, and also apparently in one case actually mined for, in the rock, by the aborigines of the country for an unknown period prior to any investigations by Europeans in the early years of the present century.

With the one exception of apparent mining in rock, all the gold was got from alluvial or surface soils by washing: and that this has been, until within the last year, the condition of gold production, is a feature which, for better or worse, must always be kept in view.

Of course, the consideration immediately follows that the gold which has been and is being obtained from these alluvial deposits must have come from some original rock source; *i.e.*, from quartz reefs, or from the walls of igneous intrusions

such as trap or greenstone dykes, or from the partings between particular bands of country rock, or, finally, from the country rock itself.

It is, practically, the settlement of this uncertainty about the original matrix of the gold which must eventually be solved in the present desire for, or attempt at, exploitation. Were, indeed, one of us, in his position of a geologist having extensive acquaintance with the auriferous tracts in Peninsular India, interrogated, as has often been the case, as to the prospects of success in Chota Nagpore as a region for gold reef-mining, he could not give a decided answer; because, although observing travellers and responsible geologists have been over the country, their examinations were not close enough, or sufficiently detailed, for the information or guidance of that gold exploitation which would naturally centre itself on reefs or other ordinary matrices of gold, concerning which, however, there is really little or no information.

It is to be remembered that the '*country rocks*' of by far the greater part of Chota Nagpore are just such as very often yield some trace of gold for the alluvial or surface deposits resulting from their degradation; and in this particular the country is no better than other crystalline areas or tracts in the Peninsula. Besides this, however, there is the known fact of the more prominent and frequent occurrence of gold sands in certain parts of the district; which parts, taken as a whole, appear to be more or less conterminous with the areas of schistose rocks, which Mr. Ball, then of the Geological Survey, followed out in considerable detail and found to be more metalliferous than the older and more extended rock series (Gneissic Formation) of Western Bengal.

This newer Sub-metamorphic or Transition, or Schistose Series, had long been known to the Geological Survey under various names in other parts of Peninsular India, as being the metalliferous or ore-deposit formation of the country; but it remained for Mr. R. Bruce Foote to distinguish a very extensive and marked representative of it, in Southern India, as the Dhárwár Series, which, for that part of the Peninsula, is essentially the series in which auriferous quartz reefs occur.

It cannot, indeed, be stated that the transition rocks of Chota Nagpore are actually Dhárwárs; but the balance of evidence so far is in favor of the conclusion that they are representatives of that series.

As the sequel will shew, it is within the area or areas of this probable representative of the Dhárwár Series in Chota Nagpore, that the main sources of gold and other ores are found; though there is also considerable reason for the inference that some of the gold in certain parts of the country must have come from certain tracts in the gneissic area.

The map accompanying this compilation shews as much of the areas of gneiss and transitions in Chota Nagpore and the adjacent districts as has been ascertained by the Geological Survey of India by actual survey, or by the careful collating of what had been written by previous observers. It is, perhaps, hardly necessary to warn the reader that the geology delineated on this map is, for a great part of the area, such as would be only visible were the superficial deposits swept off the face of the country. It would therefore be difficult for the ordinary explorer or traveller to recognize, except in

the hilly tracts, so clear an expanse of rocky formations as is displayed in the map; the general aspect of most of the country being that of wild tracts of jungle-covered ground, or uninteresting gravelly and alluvial plain, in which little would meet the eye but coarse *débris* of granite or gneiss or schist, or black and green traps and greenstone, with few pebbles or boulders of the often-longed-for quartz, out of which the gold, if there ever was any in them, had long been knocked or frittered away by rivers, rain, and weather. Practically, however, it is in the hilly tracts, or in the banks and beds of streams and rivers, that the ore-bearing rocks are to be found; and for these the map is true as far as its scale will allow.

The known auriferous conditions of the country will now be laid before the reader by a collation of all the materials extant in books or otherwise; from which, with such help as we can give between, he may be able to form an idea of what may be expected or looked for in the country, and what should be done towards any profitable development of its resources.

History and Criticism of Geological and other Explorations.

A. 1823. Voysey. Between Sambalpur and Dhadka.

The earliest recorded evidence of the existence of quartz reefs or veins in Chota Nagpore appears in the Journals of Dr. Voysey, a geologist who was attached to the Trigonometrical Survey in Southern and Central India in 1823. (See Journ. As. Soc. Beng. XIII, p. 860.)

On his way from Sambalpur to Calcutta he entered the Chota Nagpore country about Kotong, on the south-west

edge of the district, at which point we take up his journal:

"*Kotooniah*, 25th March.—The gneiss in some places passes into a mica schist, and contains, moreover, numerous beds of hornblende schist and a few of quartz rock.

"*Raootpalee* or *Hateebar*, 28th March.—The road was very uneven and stony, and the turns very numerous to ascend the ravines; the rock, gneiss passing into mica schist with numerous veins and beds of quartz rock. The latter part of the Jam Ghattee Pass is of hornblende schist, without any admixture of either felspar or quartz.

"*Chunoah*, 2nd April.—At Oargah the gneiss is laid bare to a considerable extent. In the bed of the nullah, I observed several quartz veins. To Direcola, is through a very deep forest without any cultivation, except in a small spot near Direcola. The rock is gneiss, hornblende schist, and quartz rock repeatedly alternating.

"*Cheekurdurpur*, 3rd April.—The rock around the place is gneiss, with a considerable quantity of quartz intermixed.

"*Sureekela*, 6th April.—On the road from Kishenpoor I saw gneiss in the beds of all the nullahs, and a kind of clay-stone lying in a bed in the gneiss near the Soonjee; this change is analogous to that which takes places in the Granite of Hyderabad, from greenstone into the pot-stone. Numerous large beds and elongated veins of white quartz; it is not improbable that metalliferous ores exist in this rock. It has been found the richest in metals in all the Indian rocks.

"*Idhull*, 7th April.—Granite of the lamellar kind sometimes passing into gneiss is the universal rock intermixed with beds of quartz rock, and the greenstone veins and beds. In one part I observed a large grained decomposing granite, composed of large amorphous crystallizations of white mica, felspar and quartz.

"*Bapmara* or *Bagmara*, 8th April.—I came over the concentric granite passing into gneiss, and numerous trap veins.

"*9th April. Cooliana*, left bank of the Soobunreeka, I passed a large nullah. In this short march of only nine miles I passed large masses of

quartz rocks lying in gneiss and mica schist, and found in the bed of the river Soobunreeka mica schist, with large veins of hornblende rock and greenstone.

"*Cooliana, 10th April.*—I found the rocks of the ghaut were mica schist, with veins and beds of quartz rock.

"*Dhadka, 11th April.*

* * * * * *

"The Pass of Narsingpoor, already about 300 feet above the village, is composed of mica schist passing into clay slate. I observed this rock the whole distance to Dhadka containing veins and beds of white quartz.

"*12th April.*—Rocks of Coliapal. The same mica schist with quartz veins. One specimen of quartz reminded me of axinte.

It is interesting to observe that thus early in the history of exploration the locality of Dhadka is brought into notice; although only, as far as the present enquiry goes, in connection with quartz reefs.

In the present exploitation of the country, the question of the occurrence of quartz veins and reefs is the all-important one; and although there is no mention of gold or other ores in particular in these extracts from Voysey's journal, the occurrence of quartz-rock (presumably sometimes vein quartz) is noted at Kotooniah (most likely Kotong of our map), and again on the then rough and devious road to Raootpalli or Hateebar (about 14 or 15 miles N. E. of Laingarh). At Oorga, or Orga of Atlas sheet No. 105, a few miles further N. N. E.; he again notes quartz veins. All these places except Kotong are on the Transition series.

Thence until beyond Suraikela he passed over gneissic rocks: after which he again passed on to the Transition series on his way to Dhadka.

At the Narsingpoor ghat, to be referred to again later on, he noted beds and veins of white quartz.

A reference to Ball's map of Manbhum and Singhbhum, (Memoirs, Geol: Sur: of India, XVIII. Pt. II) or to the smaller one attached to this book, will show how there are a few indications of gold washings in the neighbourhood of Bagmara, Chikurdurpur, Dhadka, and Suraikela ; although the metalliferous indications are mainly of copper, iron and lead.

The country between Hatteebar and Direcola (Diakola of present maps) certainly seems to be one of quartz impregnation either in the form of veins, reefs, or fault-rock : and as such it deserves close examination.

The greater part of the quartz rock noted by Voysey must, however, be fault-rock which, though it occurs filling in faulted cracks or fissures, is not strictly speaking reef or vein quartz.

B. 1838. Ouseley. Gold Washing, S. W. edge of area.

Major J. R. Ouseley, in a note on the process of washing for gold dust and diamonds at Heera Khoond, published in the Journ. As. Soc., Beng. VIII, p. 1057, in 1839, wrote as follows :—

"The day before yesterday I visited the Heera Khoond and saw the process of washing for gold dust and diamonds.

* * * * * *

"The gold they are allowed to dispose of; which they do at 12 or 15 rupees per tola. The veins are, I am convinced, some distance off, as the grains of gold appear flattened by collision in rolling among pebbles. I have the pleasure to send 3 mashas (½ a tola not yet brought), and some

of the rocks about the spot where the diamonds and gold dust are found. The Heera Khoond is an island about a coss long, and one or two hundred yards wide in the Mahanuddy, seven miles, seven-and-a-half furlongs from the eastern end of Sambalpur. The Heera Khoond is that part of the river which runs south of the islands. The diamonds and gold dust are said to he washed down the Ebee river, about four miles above the Heera Khoond; but as both are procurable as far as Soonpoor, I am inclined to think there may be veins of gold along the Mahanuddy. It would, however, I think, be very desirable to have this part of the country properly examined, which it never yet was. Gold washings might be undertaken on mechanical principles, which would, by reducing the manual labour, make the speculation highly profitable in gold dust alone, setting aside the diamonds.

"The season for washing is after the river subsides on the rains ceasing; but they occasionally continue until the rains again interrupt their labours.

* * * * * *

"P.S. There is also gold dust in the Brahminee river, about six marches east of this, but no diamonds."

These extracts refer to country outside of, but on the S. W. borders of Chota Nagpore. They, like so many other of the accounts which are to follow, merely describe the gold as being obtained from washings in the Mahanaddi or the country around in the neighbourhood of Sambalpur. As will be seen in the sequel, this area was visited by Mr. Ball and he was led to infer that the principal tract from whence the gold sands are derived is in the drainage area of the Eeb or Ib river. One of us also had an opportunity in 1884 of surveying part of the Ib valley, and was then led to surmise that the gold is immediately derived from the degradation of the lowest member *(Talchirs)* of the coal-bearing series in that neighbourhood: though even these sedimentary rocks must have gained it from the degradation of the still older crystalline rocks, part of the main area of which is still drained by the Ib and its tributaries.

The Ib or Eeb river has always been before those interested in the subject, through reports of its gold sands: its drainage area embraces a small portion of the tributary state of Udepur, the greater part of Jashpur, as well as a small part of Gangpur. The rocks of this combined tract are mostly of the older or gneissic series, very granitoid or granitic in its appearance and permeated with granite veins; but it is not improbable that the western end of the great tract of transition rocks (colored purple in map) may extend further westward or be represented by outliers. The country has never been closely surveyed except for the limitation and study of the coal-bearing rocks on the western frontier. This tract will be again noticed later on.

The Ib drainage need not necessarily be the sole source of gold dust; because as Ouseley notes, some portion of the supply may have been brought down from the westward by the Mahanaddi: in fact, from the Sonakhan region in the Raipur District of the Central Provinces, on the Jonk River which falls into the Mahanaddi near Seorinaraian.

C. 1840. Tickell. Gold Washing in the Hodésum.

In the following year (1840) Lieutenant Tickell published in the Journal of the Asiatic Society of Bengal (Vol IX., p. 694) a memoir on the Hodésum, a large tract of country inhabited by the Hos or Larka Kols of Singhbhum. Describing the geology of the hill ranges of this country he wrote:—

"These ranges are not of very great height, the loftiest, which are in Saruda, not appearing above 1000 feet above the plain. They are however intersected in parts by profound vallies, which give the hills, from that side, an appearance of great magnitude. They are chiefly quartz, in all stages of decomposition, permeated by limestone rocks;

smaller detached ranges issuing at right angles to these are commonly of micacious slate. From Chyebassa proceeding easterly into Koochoong are low ridges perfectly parallel, about half a mile to a mile apart, gradually increasing in height till the series is closed by the Choivria hills in Koochoong. They are composed of loose rocks resembling (if they are not) clink stone; but the larger ridges are of coarse granite. The northern part of the Kolehan consists in a great measure of sterile plains, scattered with quartz boulders, stones, and pebbles, some crystallized. The beds of the nullahs are a shingle composed of jasper (of all hues) green stone, quartz pebbles and flint. The bed of the Byturnee is lined with flattened pebbles and lumps of jasper of bright yellow, red, purple, and black, disposed in parallel streaks, or ribbands, as if artificially inlaid.

* * * * * *

The whole of these streams wash down more or less gold, but the Koles know not how to collect it In Singhbhoom a tolerable quantity is gathered by Hindoos, but of a third or fourth rate quality."

Here, again, the story is still of gold washings; though there is some evidence towards the conclusion that the gold may have been derived from the degradation or denudation of quartz veins or reefs, because of the mention of the frequent occurrence of quartz *débris* in the northern part of the Kolahan.

It is to be noted, however, that the statement that the whole of these streams wash down more or less gold points rather to a more general distribution of the metal than is usually understood from its occurrence in mineral veins proper. Still, as future reading will show, this only holds as long as evidence of quartz intrusion is not forthcoming. We have already adduced some indications, however small, against their entire absence.

It may be as well at this stage of the enquiry, to state that much of the country is marked by great fault lines, which

fault lines exhibit themselves as long and abrupt boundaries between the transitions and the gneissic rocks; or often by runs of fault-rock which take the form of great veins or dykes of quartz-breccia, that is, an amorphous or sub-granular occasionally very compact and even flinty rock of dull tints or red color with brown stains, sometimes much broken-up or joggled, but cemented into a uniform rock by infiltration of silica after the breaking up.

These runs of fault-rock, especially on their walls, are often more or less metalliferous, principally with iron or even lead and copper; though it is not altogether unlikely that in places they may be auriferous. Much of the quartz *débris* and boulders mentioned by Tickell as scattered over the plain consists of this fault-rock.

The Kolahan mentioned in the above extracts is that part of the country north of the river Sanjai: consequently the northern part referred to by Tickell as scattered over with quartz boulders, &c., lies further north of the hilly tract of Sonapet, Kharsawan, &c.; and in it the country rock is mainly gneissic or granitoid. It is still nevertheless in part a gold-producing region; for along the course of the Subhanareka across this granitoid tract, the evidences of gold washing are numerous, and naturally point to an original rock source within the drainage area of the higher reaches of this river.

The place mentioned by Lieut. Tickell as Saruda is evidently the Saranda of modern days. Mr. Ball writes nearly 40 years later of this tract:—

"In Saranda, which is a hilly elevated tract in Singhbhum, intervening between the main area of Singhbhum and Gangpur, gold is washed

for to some extent. Its occurrence in Anandapur and at Arabhanga is recorded by Colonel Haughton. The latter name does not appear on the map, but close to the former, at Dhipa, gold-washing was witnessed by the writer."

D. 1847. Ouseley. Alluvial Mines at Rabkob.

Colonel Ouseley, in a report to Government in 1847, wrote as follows regarding this locality which is in Udepur on the extreme western edge of Chota Nagpore.

"The largest mine is a quarter of a coss east of the village. The three houses of gold-diggers can only collect one or two ruttees a day.

"There are six other places where gold is found. In mouzah Kumhar on the Koorja river, in Kauraja, Salga, and Byraggy on the sides of the Sungool river at Bakarrama on the banks of the Bhurrary river, in Baghbehal at Jumergy, in one of its Tolas called Pilma or Pimla, on the banks of the Mynee river, but at all these places the quality of the gold is inferior (or white gold 'Chakha Sona') to that of Robkobe, and there are no gold-finders in any of these villages.

"There is no foreign traffic in gold, the villages exchange rice, etc., with the gold-finders of Robkobe, and only in very small quantities; it is sold at one rupee the masha, or at the rate of ten or twelve rupees the gold mohur. It would be desirable to send a person who understands these things, to the place after the rains from Calcutta, one who is able to judge of the quantity that might by scientific means be realised (this is not mere sand-washing, it is a 'khan' or mine, and may prove to be invaluable)."

In a letter dated a month later Colonel Ouseley calls attention to the surprising difference between a third supply of Rabkob gold dust, which he was then sending to Government, and the dust generally washed from the sands of a river.

"The latter description," HE SAYS, "consists invariably of minute lamina, as if in its passage among the rocks, stones, and gravels of the river, had been hammered into thin scales, this dug from the matrix, it

is observable,—is in granules of various forms—it is also of a richer hue."

Here, for the first time, mines are mentioned; but they were evidently only sunk in alluvial deposits, though, as will be seen shortly, to some depth.

E. 1849. Robinson. Mining in alluvial gravels in Jashpur and Udepur.

In an interesting Memorandum (Journ. As. Soc. Beng. XXIII, p. 103.) on the geological structure and mineral resources of the Singhbhum Division, by Captain J. C. Haughton, late Assistant to the Governor-General's Agent in the South West Frontier; a letter is quoted from a Mr. Robinson, dated Ranchi, 20th December, 1849, from which the following are extracts :—

"I now want to call your attention to another subject. *Gold mines*—real genuine gold mines. I enclose you the copies of the Official Papers about them, and proceed to add my testimony on the subject, as also some aspirations. When I came up here last year, I went on with M—to see the mines, visiting every place where they existed, and a most extraordinary sight it was—they are real mines with shafts sunk down to them varying from twenty to sixty feet in depth, all very close together because the people are afraid to run galleries under ground; in some places the old shafts are so numerous that I can only compare the country to a gigantic rabbit warren, and they must have been sunk nearly 100 years ago, notwithstanding which the soil in which the gold is found is as abundant as ever; in some places where the ground is cut by ravines and nullahs it outcrops in the banks, but these are not numerous, the shafts being the chief resource. The gold is found in several sorts of soil, a blue clay, a red clay of a very singular description, and a yellow clay full of large gravel or stones, The gold is separated from the soil by washing in wooden troughs, the principle being exactly the same as that of the *cradle* used in California, only without the slight aid of machinery applied to that plan. Another

plan and a very remarkable one in which the people collect the gold, is by drawing up small watercourses before the rains, so as to make places for a deposit of soil carried down by the water: this soil is cleaned out several times, and in it is found a large deposit of gold, proving that it exists all over this particular tract of country in large quantities. I believe that the formation of gold is still very little understood, and from my observation I am convinced that it takes place only in small particles, and in particular combinations of soil; by the action of water these particles may become collected in larger or smaller quantities in certain places, but I believe generally the gold is found where it was formed: these mines at such a depth as 60 ft. underneath jungle, and over such a large extent of country render any other supposition very improbable. It is impossible to arrive at any estimate of the total annual produce of all these mines, because the gold is carried away by native mahajuns who exchange rice, salt, &c., for it, in such an infinity of directions and the people themselves are far too primitive and ignorant to be able to give any idea upon this point. That it must be large however is certain, from the comfortable appearance of the people, and from the abundance of gold possessed by all the Rajahs, Zemindars, and other wealthy men all over the country; the regular price at which the people who work in the mines will sell the gold is Rs. 10 per tolah (R. 1 weight) but they much prefer exchanging it for rice, salt, ghee, cloth, &c.

"My journey extended as far as Robkobe in Oodipore, 220 miles hence, and finding that place was best adapted to an experiment on a small scale, water being abundant from the River Soane, I left M—there and returned here, when I got a lease of the village with liberty to work the mines from Government for seven years. The result of this trial I found to be, that basing it on a simple calculation of labour, a man to whom I paid one anna per day produced me between 3 and 4 annas worth of gold and of course this return could be increased materially, by the employment of some simple machinery for increasing the quantity of earth that a given number of men could wash in a day, and by the economy of labour arising from a well organised system of employing the men. My gold I sent down to Calcutta where it was assayed at the Mint, and proved of the value of Rs. 14⅝ per tolah, a price at which I afterwards sold it in the bazar. Robkobe however being in the very heart of the jungles, and very

low, proved so intensely hot and unhealthy that M—was obliged to come in here sick, and I had to give up the work, for I am sure no European could live there. Even this country is as little known as any in India, but 150 miles of my journey, was where *a European had never been seen before and a white face was a wonder to the people.* You need not therefore wonder that the riches of the country are at present totally unknown except to very few. Mr. Williams, the Geologist, was on his way to visit it when he was taken ill and died at Hazarebagh 40 miles hence. Now I want you to consider the following. The *best mines* are in Jushpore about 100 miles hence, 4 days' march, where the country and climate are very fine indeed, and I am quite sure that a very fine thing could be made of working them if a capital of Rs 40,000 and Rs. 50,000 could be raised for the purpose. The late Rajah Ram Singh worked them for a short time, and it is known well that their produce was very large. Unfortunately however from some ill-construction, one of the shafts fell in, killing a number of people, and he was obliged to give them up for a time : his death occurred shortly afterwards, and his son Pertab Narain Singh the present Rajah, is one of those individuals who considers doing anything for profit a degradation, and beneath his dignity. I applied to him through Colonel Ouseley for pottahs of the mines, but he replied by saying that they were let up to the end of the present settlement and he could not give them ; he is very averse to Europeans doing any thing in his country, and did his best to thwart my plans in many underhand ways : however the settlement expires next year, and it is then the intention of Government to reserve the minerals to themselves. I have had some correspondence with them on the subject. and they have now referred me to Mr. Crawford the new Agent, Colonel Ouseley's successor. He however has not had time yet to enter into the subject with me, but will do so in February when he returns here from his tour in the district, and I have no doubt I shall be able to get a lease of the mines for a good term of years. *Gold mines* is a very large word, but there is in this case no nonsense about it : I have seen the thing myself, and, without stating any Californian ideas, know that these mines must pay splendidly to whoever gets them."

The regions examined by Mr. Robinson are stated to be in the Jashpur State on the extreme western edge of Chota

Nagpore; and again at Rabkob, which is some forty miles further W. S. W. in the Udepur State. These two States seem to have been the only places of proper mining work in, and at the bottom of, the older alluvial deposits: so that there is clearly, in this far-away and thinly inhabited country, a deposit which is of sufficient extent to encourage hopes of a possible field of alluvial mining which may pay. We know of no other tract in Peninsular India where the conditions appear to approach, though of course to a much lesser extent, those of the Australian or American alluvial gold deposits. Mr. Ball, in writing generally of the States of Gangpur and Udepur, is disposed to consider that the facts before him "establish beyond a possibility of doubt the existence of an ancient alluvial gold-bearing deposit at intervals throughout a tract not far short of 2,000 square miles in area." He, however, qualifies the apparent grandeur of this prospect by the remark that a considerable portion of this area is hilly, meaning thereby that it is rocky, and therefore that the intervals of alluvial country probably constitute the smaller portion of the whole area.

It is as well to note that these are *alluvial mines*, and not *rock mines*, or such as would be excavated in reefs or veins. Most of the gold occurrences in Chota Nagpore are merely in surface or river sands, from which the ore is obtained direct by washing, and this form of collection of gold is very precarious and of fitful operation. The occurrence, therefore, of any large enough tracts of older alluvial gravels is a question of very great importance; while the original source of their gold might reasonably be expected to exist at no great distance from them.

In Jashpur and Gangpur, however, the country is mainly a

crystalline, or sub-metamorphic one, as far as is known ; and in it there is abundant room for the occurrence of quartz reefs and fault-rock, some of which may be auriferous.

F. 1854. Haughton. Gold in Singhbhum.

Captain Haughton himself, in the Memorandum referred to above, writes as follows, regarding the gold in Singhbhoom :—

"This metal is found in almost every river and stream in the country. The apparent exceptions are those which flow almost entirely over igneous rocks. I cannot learn that the metal is found anywhere in the Khurkhy, and an attempt to extract it from the sands of that river made under my direction failed. The sands of the Roro and its other tributaries were not known to contain it ; but on examination a small quantity was extracted from the sands of the Roro and Eleegara by people deputed for the purpose.

"I believe gold is found in most parts of the Sooburno Rekha, from the point where it quits the gneiss formation till it falls into the Bay of Bengal. I know certainly that it is found so low as Kamerara, on the boundary of Dholbhoom and Mohrbunje.

" Gold is found on the surface of the soil at Arabhanga and other places among the wild jungles of Sarunda ; in Anundpore, at Badea in Dholbhoom close to the old copper diggings, and probably in other places. There is a tradition of a mine in the jungles of Porahat, from whence large quantities are said to have been formerly extracted. This mine is stated to have been driven horizontally from the bed of a nullah into a hill ; it is now said to be completely choked with rubbish. I have seen specimens of the gold from the stream close by, which would lead to the belief that the original source was not far off, the gold being often in short wiry threads, or in little rings. All I had from this source I made over to Mr. Robinson when in this quarter, more is not procurable in the rains.

" Gold is found in situ near a slight eminence a little north of Asuntullea in Khursowa, to the west of the road. It cannot however be very plentiful, as few take the trouble to look for t. This spot is well worthy of a

careful examination, as being the highest in the immediate neighbourhood, the metal must be derived from the rocks which there are just obtruded from the soil.

"It is very difficult to estimate at what rate the metal might be produced, as it is seldom searched for, except to order. The ghassees, the lowest class in the country, who wash for it, always demand an advance before they will set to work, and at the same time steadily refuse to work by the day, insisting on selling it at a fixed rate to their employer. They can always reckon on earning from three to four pice per day, and I am assured that a vigorous man often gets as much as twelve annas, which, as the ordinary rate of the field labourers' hire is about one pice, must be considered a very large sum.

"The metal was found some years ago in considerable lumps in the Sona Nuddee of Sonapet in Tamar, on the northern extremity of Singhbhoom; and much is still found there; but the lucky man who got the 'Nuggets' is believed to have kept his secret to himself.

"The gold of Sonapet is considered the best. The price varies from ten to seventeen rupees per tola. I think it probable that a much greater amount might be extracted, and great labour saved by treating the residuary sand, found after the coarse gravel is got rid of with mercury; I have collected some of the sand that this question may be decided; also with a view to examination for other metals which elsewhere are found to accompany gold.

"The process of washing has often been described. A wooden tray like those used by butchers in England and an iron hook to loosen the gravel with are the only implements. The labourer may be seen after his day-work melting the result, with a bamboo tube for a blowpipe, and a little bit of borax as a flux, at a common wood fire, where several work together they weigh it on the spot and decide the share of each. In Tamar during the dry season numerous parties assemble and dig great pits in the bed of the Kurkuree rivers, but anything approaching to a mine, I have not seen.

"The spots where gold is found most abundantly are those where the strongest currents of the streams are met by a bank of the river.

"My own belief is, that the precious metal is derived chiefly from the metamorphic rocks, *i.e.*, slates and schists which have been altered by the

action of fire. The natives do not appear to have any suspicion as to its source, and I have not heard of any instance in which the metal has been found attached to stone.

"Quartz and large quartz-dykes abound. I have searched the soil without success in the neighbourhood of some of the largest dykes. The stone itself has yet to be examined."

An important passage in this very interesting and straightforward account of the occurrence of gold, is the last paragraph wherein the existence of quartz reefs is vouched for; though unfortunately they are not localised. It is nothing against them that the soil in their neighbourhood has failed to yield gold by washing: the gold they yielded, if it ever existed, must have been carried to lower and more distant levels ages ago; while there is ever a tendency in the contents of a quartz reef to be washed out, or down into its depths, from the portion exposed to weathering influences. It is tolerably well ascertained that the goodness or badness of a reef can never be fairly estimated unless that reef has been cut into at least some twenty or thirty feet below the level of the top edge of the soil cap.

The next point of interest, is the tradition of a mine in the jungles of Porahat which is stated to have been driven horizontally from the bed of a nulla into a hill. Certainly, the form of the particles of gold which Captain Haughton saw from the stream close by is strong evidence of proximity of original matrix.

As the sequel will show, this is the one and only place where there is even a tradition of a rock-mine supposed to have yielded gold; although there is plenty of evidence of extensive rock-mining for copper and other base metals.

Captain Haughton, who seems to have gone over the ground most carefully in search of the source of the gold, formed several valuable and noteworthy conclusions as to the *locale* of the gold sand. He was led to conclude that the gold dust did not apparently occur in the sands of the streams flowing almost entirely over igneous rocks, meaning, it is presumed, the great belt of trap or greenstone (marked on our map by green color) as distinguishable from the other igneous rock, granite, which only occurs in small veins or outbursts, except in the northern part of the country in the neighbourhood of Purulia. As for the source of the gold itself, he certainly seems to favor the view that it is in the main derivable from the country rock rather than from reefs of quartz.

G. 1860. Stoehr.

The first properly scientific account of the mineral resources of a part of Chota Nagpore was given by Mr. Emil Stoehr in two papers on *The Copper Mines of Singhbhum.*

A translation from these papers, apparently by Mr. Ball, was given in the Records of the Geological Survey of India, Vol. III, p. 86 (1870). The subject is properly an account of the copper mines, but the part bearing on the geology proper is worthy of extract at this stage of the discussion.

Mr. Ball subsequently relates in his Memoir on the Geology of Manbhum and Singhbhum, how "Dr. Stoehr came to India in the year 1855 at the request of two Calcutta firms to examine the copper-bearing rocks to which Colonel Haughton had drawn attention, and to assist in the formation of a Company, should his report recommend it."

Dr. Stoehr writes :—

"1. *General Geological features; Schists.*—It is only in the south and west of the region under notice that granite and gneiss-granite appear, forming dome-shaped hillocks seldom more than 100 feet above the flat. The old rock-formations—metamorphics—of Lyell behave very differently; they form a system of parallel ridges from west-north-west to east-south-east, ranging in elevation to 1,900 feet and under. The strike of the ridges is for the most part the same as that of the schists, except in a few places to the east; up to Sideshor the strike varies from east-7°-south to east-30-°south; from there it is east 37° to 60°-south. The dip s constantly to northwards, at from 15° to 50°, mostly from 20° to 35°. This structure decides the form of the hills—steep on the south and sloping on the north.

"These schists present many varieties, scarcely any form of metamorphic rock is unrepresented; clay-slate of the most various types, from soft clay-slate to roofing slate, with quartzose varieties, or sometimes quartzites, forming the ridges; mica-, chlorite-, talc-, hornblende-, and quartz-schist with quartz-rock are the most prevalent. Occasionally gneiss is found, but without any continuity or constant position in the series. There is a peculiar rock composed of round grains of quartz in great number (often exceeding the matrix) in a base of clay-slate. At the junction of the sedimentaries and the granitics there occurs a strange quartzose formation, a true arkose, many feet thick and almost vertical; in which are found angular fragments of the different metamorphics, in a fine quartzose mass. Of minerals I obtained garnet, schorl, kyanite, rhatizite, and chloritoid (of Kenngott); also a blue-black mineral of an elongated form, which Kenngott considered to be apatite united with a carbonaceous substance.

"2. *Greenstone dykes.*—The irregularities that these ranges exhibit are due to the presence of transverse dykes, especially of diorite. Simple inspection cannot determine whether the greenstone is amphibolic or pyroxenic—diorite or diabase; I incline to consider it diorite. Generally hard, it often becomes soft, changing to aphanite; at Paraum near Dhoba it is almost serpentinous, containing nearly 10 per cent. of water. Not far off are considerable runs of potstone, which this aphanite seems at all

events to approach. In other places the greenstone passes into greenstone-schist following the strike of the series. Although these dykes do not always come to the surface, they can be traced at intervals in long ridges recognisable from a distance as longitudinally extended lines of conical hills, generally double-topped The strike of these diorite masses varies, generally north and south, or 15° on either side. Where such a north-south range crosses those of the older rocks all is confused ; still a most picturesque conical hill always detaches itself from the mass. This very hornblendic diorite has a remarkable tendency to spheroidal structure, and appears on the summits split into vertical columns, like ruined castles. It is noteworthy that one often finds such clefts with quite fresh surfaces of fracture : this is the result of the sudden cooling by rain of the rocks when highly heated by the sun's rays, as I determined by direct experiment. These diorites are so rich in iron that they often disturb the magnetic needle, and weather into iron-sand. The diorite cones seldom form considerable elevations ; but this is not without exception, as at Bagmuri, 2,000 feet high. Where the diorites come in contact with the sedimentaries these are altogether metamorphosed ; basalt jasper occurs ; the schists are calcined, and columnar divisions are frequent. These greenstones are not limited to the north and south dykes.

" 3. *Granitics.*—These diorites run into the granitic area to the south and west ; where gneiss-granite and, less frequently, true granite form dome-shaped hills ; these also here observe an east-west direction in long parallel ranges above the plain, traversed by the north-south diorites—an arrangement that gives to the whole area a strange chessboard-like aspect. At the intersections of the two systems of ranges, the most picturesque cones occur; and remarkable development of mica appears in the granitic rock, so that the mica is applied to many ornamental purposes.

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" At Akarsuni with black mica-schist and quartzose clay-slate, close to greenstone ; granite also shows in the neighbourhood. The detritus on this granite is washed for gold.

* * * * * *

" The northern run at Landu is in quartzose schist accompanied by mica- and chlorite-schist : the southern in mica- and chlorite-schist with associated quartz."

The foregoing extracts are mainly descriptive of the geology of the country; but the reader must now, as the examination of the ground passes into professional hands, be prepared to consider the conditions in their geological aspects; and to that end, we will in some sort endeavour to guide him through such technical and seemingly difficult and uninteresting details.

It must, however, have become patent to the reader that the country is largely one of rocks which usually go by the name of the gneissic or crystalline series; that is, a series of more or less amorphous granular or granular crystalline rocks composed of such minerals as quartz, felspar, hornblende, and mica. These generally resemble granite, or syenite, only that they are foliated or streaked. They are also often traversed by, or permeated with, veins, strings, reefs, and dykes of granite or quartz, or greenstone, or trap, or fault-rock.

Or again, a particular belt of the country consists of the Sub-Metamorphic or Transition Series; which is a series of less crystallized rocks, strongly speciallized as being schistose or highly foliated, giving such varieties as micaceous, or hornblendic, or chloritic, or talcose, or quartzose schists, all having a more or less quartzose or sandy and felspathic element in their constitution. These rocks are generally schistose; but they often occur massive when the hornblende, or the chlorite, or the talc (not mica), or the quartz becomes the predominating mineral; and then the varieties are called quartzite (a highly altered and vitrified sandstone), hornblende rock (approaching, in appearance, greenstone or trap), chlorite rock, and talcose rock of which potstone is a massive variety. It is this series of rocks (the Transitions, or Sub-metamorphics, ? Dhárwárs) which is ore-bearing in India: and, as a rule, the metalliferous exhibi-

tions occur in veins, reefs, dykes, runs, &c., of quartz, or quartz-rock (fault-rock), traversing, permeating, or running with, the bedding of the schists.

Ore deposits also occur frequently, and sometimes only, on the walls of these dykes, and reefs; or, for a very short distance within the country rock in contact with them.

Dr. Stoehr writes of the gneissic or crystalline series, as gneiss-granite: but it is he who first recognizes on scientific grounds the existence in Singhbhum of the sub-metamorphics or transitions, which he also sometimes calls sedimentaries, as well as schists, from their often stratified look and other evidence of sedimentation or deposition.

He noted "a strange quartzose formation, a true arkose, many feet thick and vertical: in which there are found angular fragments of the different metamorphics, in a fine quartzose mass." This was probably a form of fault-rock to which we have already referred as forming great walls, and back-bones of ridges in or along the western edge of the great belt of Transitions (colored purple in the map); and which is always worth probing for metalliferous contents.

The schists form a great, generally east-west, belt, as shown on the map in purple color: and with them at intervals, run huge dykes and apparent flows of dark green and black greenstones, diorites, and traps. This schistose tract is highly metalliferous according to Dr. Stoehr: but in only one case does he refer to gold as possibly coming from them, and this was in the neighbourhood of granite or granitic rocks associated with schists. He must necessarily have heard of

the frequent surface occurrence of gold sands: but his business was the exploration of copper ores; and to a report on them he seems to have confined himself.

H. 1863. Dalton. Gold Washing in Jashpur.

The following account of the operation of washing for gold in Jashpur, as carried on by the natives of the country, is given in his *Notes of a Tour in the Tributary Mehals*, in 1863-64, by Col. T. Dalton. (Journ. As. Soc. Beng., XXIV, Pt. II, p. 51.)

"The Eeb river * * * is also called the 'Heera' river, as diamonds are found in its bed, and it is probably the source of the diamond stores of the Maha Nuddee, as I understand that none have been found above the confluence of the two streams. It is auriferous, and from time immemorial its sands and deposits have been explored by hereditary gold-washers, called 'Jhoras.' These gold-washers do not, however, confine their operations to the bed of the river. They find it more profitable to penetrate the soil some distance from its banks, and on both sides you find tracts honey-combed with shafts, sunk by successive generations of gold seekers.

"These shafts are from 10 to 30 feet in depth, and three in diameter. The Jhoras excavate till they cut through the upper stratum of vegetable mould and the red soil beneath it, and come to a layer of pebbles and fragments, chiefly of quartz, forming a dirty damp gravel; this they remove and wash. I have watched their operations close along the bank of the river, and at some miles distant from the stream, and the process and result was much the same in both places. Near the river, five pits or shafts had been recently sunk by as many families of Jhoras, for they work in families, women and children assisting. They had one washing trough, called a 'dooin,' to each family, and the washing commenced in my presence. The stuff selected is either of a dirty drab or of a reddish colour, with occasional small white spots, little balls of particles of decomposed felspar, adhering together from moisture, and drying into powder. The Jhoras regard these white spots as the surest indication that the gravel contains gold. The stratum of gravel which they were

working on this occasion was not more than a foot in depth. It rests on decomposed granite, which crumbles when taken in the hand, and the gold-washers assured me that this contained no gold, but I insisted on having some of it washed, and found their statement not strictly correct. It contains gold, but is less rich in the mineral than the gravel above. When the gravel immediately under the shaft is all removed, they scoop out from the sides all round as far as they dare venture to penetrate laterally, and in this way sometimes connect the shafts, but they take no precautions, and sometimes, going too far, have to be dug out, not always alive! There appear to have been several accidents of the kind, but with all this danger and labour, the pursuit does not return sufficient to support them, and they are farmers as well as gold-washers.

"They are greedy and reckless in taking advances, trusting much, no doubt, to the facilities their remote situation gives them, of evading payment, and some of them are enormously in debt. One man was pointed out to me as owing Rs. 1,000! He grinned as the sum was mentioned, as if exulting over his victim. The greed for gold and the gambling nature of the pursuit is surely a great corrupter of human nature, for in the midst of a population generally remarkable for honesty, truthfulness and simplicity, these gold-washers are mendacious and unscrupulous rogues.

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"The yield of these pits in gold is of course very uncertain. The outturn obtained in my presence from the five pits, in about four hours, would not have given to the individuals employed, more than half-an-anna a head, but they admitted that they sometimes obtained as much as half a tolah of gold from one 'dooin' in a day, and this would give about Rs. 2 a head to the hands employed, and make up for many blank days. From their mode of washing, there must be great waste. I observed it is only very palpable particles of gold, that are retained. The grains are irregularly shaped, with sharp angles, and do not appear to have undergone any disturbing process since they were evolved from their original matrix There is no indication of flattening or rolling out."

Regarding gold in Udepur, Col. Dalton wrote as follows:—

"The production of the precious metal is restricted by the limited number of gold-washers. There are now only six families of that profession on

the estate. The same cause may be assigned for the limited production of iron, as there are not more than ten families of smelters in all Oodeypore. I saw the gold-washers at work in pits similar to those I inspected at Jushpore. The deposit sought and the method of working it is the same in both mehals, but the deposit in Jushpore is supposed to be the richer of the two In Oodeypore, the gold-washers produced, as the result of a day's labour, only 3 grains of gold to each 'dooin' or trough, but I am satisfied from what I saw of the quantity of gold exhibited at each washing out of the trough, that they must have obtained very much more than they thought proper to produce.

"The Rajah was with me; he wishes to obtain a monopoly of the gold trade; and it did not suit them that he should see a better yield."

Although Col. Dalton's account is only of the manner of working the alluvial gold, concerning which there could hardly be a more descriptive and unvarnished story, there are several passages in it well worthy of consideration as to areas referred to, the deposit in which the gold dust occurs, and the rocks from which the metal may have been originally extracted by the forces of denudation.

In the first place, two of the States or mehals are treated of in particular. Jashpur and Udepur,—to which we will add Gangpur, because the Ib or Eeb river drainage is included in the three, mainly however in Jashpur and Gangpur; while the Ib, as has already appeared, has always been prominent as a gold-washing region. No localities are given by Col. Dalton: he only treats generally of this mining, as if almost anywhere up the river valley and those of its tributaries, wherever there is any width of alluvial deposits, these alluvial strata are probed to the bottom for a particular layer or bed of gravelly clay in which gold occurs. From his description we make out that this old and bottom bed is a

lateritized or lateritic form of débris derived from the degradation of gneissic and granitic rocks which must have formed in ancient days the basis of the country now in great part drained by the Ib river. At any rate, the conditions of drainage and depositions are so different now-a-days; that the probability is that the greater part of whatever gold is now denuded from the Gangpur, Jashpur and Udepur country is carried well into the Mahanaddi deposits; the Ib being now more of a denuding river than a depositing one. So that, the present poorness of the sand washings on the surface does not necessarily imply poverty of the country rock now under drainage.

Col. Dalton's experimental working of the gneissic, or country-rock, immediately below the auriferous gravel, does not prove much. As a general rule, the gneiss of the region under description is easily weathered, and in many cases the lateritized gravelly clay overlying it being made up of the *débris* of similar rock does not by covering the undenuded gneiss stop decay or weathering; indeed it rather tends to assist it, and to such an extent that it is often very difficult to say which is gravel, or which is weathered gneiss at the junction of the two. Thus, the little gold found by Col. Dalton may still have been in part of the deposit having a gneissic facies; or, which is more probable, it may have been carried down by filtration from the gravelly deposit into the interstices of the decomposed or weathered gneiss underneath.

Col. Dalton was naturally inclined to believe that the gold occurs distributed through the gneiss rocks. Our argument qualifies this so far, that the gold is not necessarily so derived; in fact that it may also have been extracted by denuding forces from particular gold-bearing rocks, undegraded portions

of which may still exist in the Ib drainage. It is to be noted that this gravelly layer is full of pebbles and fragments chiefly of quartz; while the matrix is evidently in great part highly felspathic. The white spots particularly mentioned are common to these lateritic gravelly clays; and are mainly a lithomarge.

I. 1868-81. Ball. Singhbhum, &c.

In 1860, the examination of Singhbhum was taken up by Mr. Ball and Mr. Ormsby of the Geological Survey of India; and in 1868 a paper, *On the Occurrence of Gold in the District of Singhbhum*, was contributed to the Records of the Department by the former gentleman.

We have already given original extracts from the previous literature, so there is no necessity to repeat his quotations therefrom. His cited observations are here given, one series of which dealing with the proportionate occurrence of gold in the crystalline and sub-metamorphic areas, is of great value.

"I have invariably found that the washers have traditions of nuggets having been found at intervals.

"The cases of the gold having been found *in situ* are undoubtedly rare. Colonel Haughton speaks of it occurring in (*in situ ?*) 'a little north of Assuntitlea in Khursowa,' but further on he states 'I have not heard of any instance in which the metal has been found attached to a stone, so that the former statement must only mean to imply that it is mined for in superficial deposits.' Dr. Emil Stœhr states that traces of gold were found in the copper ores of Singhbhum.

"A Mr. Emerson was specially employed by the Singhbhum Copper Company to investigate the gold resources of the country. He is said to have crushed a quantity of quartz and to have found traces of gold in it; but his operations do not appear to have been sufficiently successful to encourage him to continue.

"When in Chaibassa last April, I was shewn a small nugget of gold in a quartz matrix. It was said to have been obtained in the Kappergudee Ghat near Kalkapur in Dholbhum.

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"During the season of 1866-67, Mr. Ormsby and myself fancied we were able to connect the occurrence of gold in the streams with the existence of certain sub-metamorphic rocks (magnesian and mica schists, slates and quartzites) which were then for the first time met with in Manbhum.

"Being anxious to put this connection to as rigid a test as circumstances would admit of, and wishing to define, if possible, the exact boundaries within which gold certainly exists and may be reasonably looked for, I with some difficulty persuaded two gold-washers (man and wife) to accompany me during my examination of the remaining portion of the district of Manbhum They remained with me for upwards of three months, washing daily at such places as I pointed out.

"One of the most interesting results is, that the existence of gold in the metamorphic as well as the sub-metamorphic rocks has been satisfactorily proved. This, from various reasons, I was not prepared to expect. Colonel Haughton, who speaks of the granitic gneissose rocks as *igneous*, states that gold is never found in the streams traversing them. Again, the Natives, so far as my experience goes, do not wash in the sands, &c., lying on the metamorphic rocks, although they do not connect the existence of gold in the sands with the vicinity of any particular rock.

"In Manbhum, the experience of generations of washers has enabled them to define the boundaries within which washing is remunerative: and this boundary, it is interesting to observe, corresponds on the north exactly with that of the sub-metamorphic rock.* This coincidence I ascertained in the following manner. On my arrival at Dulmi (which is situated on the faulted boundary of these two groups of rocks) when marching northwards from the lower part of Pattrum, the gold-washer asked to be allowed to return to his own country (Dhalbhum), stating that none of his race ever went north of Dulmi. I induced him however to stop, and

* A line drawn across the southern part of Manbhum from Simlapal on the east through Burrabazar to a little north of Echagurh on the west, roughly indicates the position of the line of boundary between the two formations.

while we remained north of the fault the washings were carried on in the granitic gneiss area with comparatively poor, but not exactly barren, results. On the day I crossed the fault south of Sindaree, when returning southwards, the gold-washer said that we should after that find gold more regularly and in greater quantities than we had done since we came north at Dulmi

"During the whole time, a record was kept of the daily results and of the nature of the rocks in which the washings were made The following abstract will suffice for comparison of the productiveness of the two formations :—

Sub-metamorphics.

	January.	February	March.	April.	TOTAL.
Number of days on which washings were made .	31	9	18	8	66.
Unsuccessful days ..	2	3	2	2	9=3·6 per cent.
Gold in grains ..	17·68	4 65	7·6	2·45	32·38.
Daily average in grains ..	57	·516	·4	·3	Daily average for whole period = 46 grains.

Metamorphics.

	January	February	March	April.	TOTAL.
Number of days on which washings were made ..	..	20	13	..	33.
Unsuccessful days ...		13	9	..	22=66 per cent.
Total gold in grains ...	..	4·78	·7	..	5·48.
Daily average	..	·23	·05	..	Daily average for whole period $\frac{5·48}{33}$ =·16.

"Comparing these results by the number of successful days first, we may say, that for gold-producing, the sub-metamorphic rocks are to the

metamorphics as (100—13·6=)86·4 to (100—66=)34=2·5 : 1; comparing by daily average, the proportions become ·46 : ·16=q. p. 3 : 1.

"We may therefore conclude that the sub-metamorphics are between two and half and three times as productive of gold as the metamorphics, so that as the gold-washers only find a subsistence from washing in the sub-metamorphic area, it is obvious that it would not pay them to work in the metamorphics.

"The greatest amount found on one day was 2·2 grains, but the daily averages given above should not be taken as indicative of the amount of gold to be found by a regular system of working where the washers would of course be set at favorable spots, and would not have to spend a considerable portion of their time daily, as was the case of the men I employed, in making marches before they reached the scene of their labours.*

"Various papers in the Asiatic Society's Journal describe the methods of gold-washing practised in different parts of India. The instruments used, though essentially the same in principle throughout, have local peculiarities of shape, &c., and the manner of manipulation also varies.

* * * * * *

"In Manbhum and Singhbhum the instruments used are perhaps more simple than those used in any other place. The dish measures 28″ by 18″; it is hollowed somewhat eccentrically to a maximum depth of about 2½ inches. A scraper formed of a flattened ironhook set in a handle, serves to collect the auriferous sand and gravel which accumulates in the angles of the rocks in the beds of streams. The dish when filled is placed

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* It is conceivable that the fact of the greater quantity of gold being found in the superficial deposits within the sub-metamorphic area might be attributable to something in the configuration or elevation of the ground conducive to the greater accumulation of gold within that area. I could not however discover anything of this kind; the fall to south is gradual throughout both formations.

The origin of the gold which is annually found in the rivers at present is, I believe, twofold. A portion being directly derived from the rocks and the remainder resulting from the re-assortment of detritus which is the remnant of sub-aerial action.

In both formations, the evidences of extensive sub-aerial action are numerous and prominent, and it is obvious that nature has been carrying on gold washing operations in the valleys, since denudation first commenced to scoop them out, leaving barriers of intervening ranges of hills formed of the hardest rocks between them.

in shallow water, and the operator working with his hands soon separates and throws aside all the coarser gravel and stones, while the agitation of the water serves to carry away all the mud and lighter portions.

"The dish is then balanced on the palm of the left hand and oscillated to and fro with the right; this serves to throw off the greater portion o the remaining gravel, and the process is completed by a circular motion, which is communicated to the water in the hollow of the dish, by which even the smallest particles of foreign matter are separated, and the final result is a residue of black iron-sand in which the specks of gold are readily apparent.

* * * * * *

"The daily earnings of the gold-washers are small, but might no doubt be increased, if it were not that they are always satisfied when enough gold has been found for procuring the day's subsistence.

"The men I met with stated that they could earn about an anna a day and occasionally three or four annas.

"Taking into consideration the manner in which the gold is distributed through the superficial deposits of these districts, it would seem that the system of hydraulic mining, at present practised in California, is the one which would be most likely to be successful.

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"In parts of the districts under consideration it would be hopeless to expect to obtain a constant and sufficient supply of water with the necessary head-way: but there must be many places at the bases of the plateaux which rise towards the west, where the conditions would be peculiarly favourable. During the rains the number of such places would of course be vastly increased."

The remarkable feature in this description is that there is no account of any quartz reefs or other special lode, medium, or matrix in which the gold might occur. Mr. Ball's observations appear to have been such that he was led rather to enquire into the proportion of gold washed from sands occurring on areas of the gneissic or crystalline, and the sub-metamorphic or transition, or presumable Dhárwár, rocks.

We think it is quite manifest from this that in any case quartz-reefs were not of such magnitude as to have attracted his attention to them as such: and certainly, so far, the balance of evidence is more in favor of the gold being distributed through the country rock: and mainly in that of the submetamorphic area, that is, in the country colored purple on our map.

One exceptional case is however to be noted, where Mr. Ball says: "When in Chaibassa last April, I was shown a small nugget of gold in a quartz matrix. It was said to have been obtained in the Kaparguddee Ghat near Kalkapur in Dholbhum." Here he distinctly notes the quartz matrix, though, of course, it is not an uncommon thing to find quartz attached to or enclosed in undoubted alluvial nuggets.

The following is an extract from a paper by Mr. Ball on the *Diamonds, Gold and Lead Ores of the Sambalpur District*, published in the Records of the Geological Survey of India in 1877:—

"In all probability gold occurs pretty generally throughout these portions of the district in which metamorphic rocks prevail. So far as I have been able to gather from personal observation, the washers confine themselves to the beds of the Mahanadi and Ebe; but in the rains they are said to leave the larger rivers and wash in the small jungle streams.

"In the Ebe below Tahood, I saw a party of gold-washers encamped on the sand. The places where they were actually washing were within the area occupied by rocks of Talchir age; but whether the gold was proximately derived from the Talchirs or had been brought down by the river, as is possible, from the metamorphic rocks, a short distance higher up, I am unable to say.

"There is of course no *primâ facie* improbability in the Talchir rocks containing gold. On the contrary, the boulder bed, including, as it does, such a large proportion of materials directly derived from the metamorphic rocks might naturally be expected to contain gold. In the original description of the Talchir coal-field the following passage occurs:—'Gold is occasionally washed in the Tikaria river, and was also a few years since obtained from the sands of the Ouli.' The latter case is rather interesting since the localities are in a sandstone country through which the Ouli mainly flows. In this connection it may be mentioned that in Australia, quite recently, a conglomerate bed of carboniferous age has been found to be auriferous."

This extract is interesting as pointing to the possibility of some of the gold sands at any rate having been derived from the lowest member (Talchirs) of the coal-bearing series in the Ib valley. We have already referred to this view. Of course, any gold occurring in the Talchirs must have been derived from pre-existing rocks which certainly in this part of India would have been either of the gneissic or transition series; and it is quite possible that some of the existing areas of these series in Jashpur and Udepur, from which the Talchirs have long been denuded, still hold the remains of the rocks from which the Talchir gold was derived.

The Rabkob locality in Udepur is one where the gold sands may be derived from Talchirs in the immediate neighbourhood; or from reefs in the crystallines of the upper reaches of the Mand river.

It is necessary at this stage of our compilation of the material available towards a knowledge of the occurrence of gold in Chota Nagpore to point out that the work of the Geological Survey in this country was not devoted in any special

way to the examination of its gold production. The survey was a strictly geological one, that is, it was made to ascertain the different geological formations of the country of which until then there was no systematic or detailed knowledge. Primarily, the extent and localization of the great coal-bearing series of India was a main object of research; and for the limitation of the occurrence of that series of rocks, the examination of the country between the coal areas of the Mahanadi and Damuda drainages was a necessity. Thus the great tract of gneissic and metamorphic rocks of Chota Nagpore was surveyed with sufficient detail to enable the surveyors to note generally the occurrence of metalliferous deposits. But there was no special survey for gold-bearing reefs or rocks, or for any particular ore. In this way, although the survey by Messrs. Ball and Ormsby was begun in 1862, and continued until 1868; no special memoir on the geology of the country was published until 1881, when Mr. Ball's contribution on the *Geology of Manbhum and Singhbhum*, was published in the Memoirs of the Geological Survey of India, Vol. XVIII, Part 2.

Before that, however, the third part (Economic Geology, by V. Ball) of the Manual of the Geology of India, was issued by the department; and in this Mr. Ball has given a most complete account of his observations on the gold resources of Chota Nagpore.

It is unnecessary here to reproduce this admirable account in full, because much of the material utilized by the author has been given in the preceding pages: but certain passages of independent value are extracted.

We also cannot do better than preface our quotations with a portion of his opening general remarks :—

"Although the values of all mineral deposits are apt to be overrated not only by the general public but also by persons possessing a little knowledge of the subject, there is perhaps not one of them with regard to which more unsound and fallacious arguments, or what are supposed to be arguments are applied than to gold.

"It is commonly said of countries where gold-bearing sands are found that there must necessarily be some source where the gold occurs in abundance. By actual and dearly bought experience, no less than by general considerations, the falsity of this conclusion has over and over been demonstrated ; but as it continues to be asserted and re-asserted to this day, it will not be out of place, by way of cautionary prelude to what follows, to re-state the grounds upon which the proof that it is an error depends.

"There is one point upon which all modern geologists agree, and that is that the subaerial degradation and erosion of the surface by the action of rain and rivers have been going on in the same manner as they do at present for an enormously long period of time. Huge valleys have thus been scooped out by streams, which there is reason to believe, were in many cases never larger than they are now. A feeble force acting for a long time, whether the force be physical or chemical, is capable of producing results so stupendous that the aid of catastrophes is commonly invoked to account for the resultant phenomena. If it be admitted, as indeed it must be, that vast masses of materials have been carried down by streams, their valleys representing the amount of this kind of work which has been done, it can not be denied that the sifting action of such streams would tend to concentrate the heaviest particles in the nooks and crannies, and carry away the lighter ores ; this is precisely what explains an apparent abundance of gold in a virgin stream. The gold may have originally occurred very sparsely disseminated through an enormous mass of materials, but by the concentrating process which has been so long in operation, nature has done the heaviest part of the work which the gold-washer completes. He soon finds out, as it has been found out all over the world, that the amount of gold brought down in a single year gives him insignificant re-

turns, and, in time, an area becomes practically exhausted as regards its alluvial gold, though in a country like India, where a man can live or so small a sum, it is possible to derive a subsistence, such as it is, from the washings of a few rivers year after year in succession.

"It is a known fact that certain metals occur in solution in sea-water, but it does not necessarily follow that it would pay to extract them. Similarly, many metals occur very sparsely disseminated in rocks and soils. It is a mistake to suppose for instance, that gold occurs only in quartz reefs; it often exists in minute quantities in schistose and other rocks, and perhaps, in the majority of cases it is either absent or only present as a trace even in quartz reefs; so that the mere presence of gold in alluvial deposits does not necessarily prove the existence of a rich source. The man who knows that the value of a sovereign is hidden at a certain depth beneath the surface, and who thereupon expends and equal, not to say a greater, sum in its extraction, is not a wise person. The chance of drawing prizes in the mining lottery causes many people to do what is still more rash and foolish than that attributed to the above imaginary person.

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"The ultimate derivation of most of the gold of Peninsular India is doubtless from the quartz reefs which occur traversing the metamorphic and sub-metamorphic series of rocks, but there is evidence to show that in some parts of the country gold occurs in certain chloritic schists and quartzites, and possibly also in some forms of gneiss independently of quartz veins. As to the relative productiveness of the reefs in the different groups or series of metamorphosed rocks, the imperfect evidence which at present exists is somewhat conflicting. The truth of the matter probably is that there is no rule applicable to the whole of the country. What may be true in Western Bengal, namely, that in so far as the amount of alluvial gold affords a safe guide, the general productiveness of the sub-metamorphic to the metamorphic rocks is as 2·5 or 3 to 1, is not necessarily true of other areas.

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"*Bengal, Midnapur District.*—In the Midnapur District there were 21 professional gold-washers, according to the census returns. There is no published record of the actual spots where washing is practised, but

they must be situated in the beds of the Kasai (Cossye) river and its tributaries. Throughout the greater part of the district deposits of alluvium and laterite prevail, but the older crystalline and the sub-metamorphic rocks are exposed on the Western frontier which adjoins Manbhum and Singhbhum.

"In the year 1855, a sample of gold dust from Midnapur, which was forwarded by Lieutenant W. D. Short, Executive Engineer, was examined by Mr. Piddington, who discovered in it some particles of a yellowish-white mineral, which was 'malleable and tough, would not amalgamate with mercury, and was excessively difficult of solution in boiling *aqua regia*, though it certainly contained gold.' He was inclined to believe that it may be a sulphuret of gold, an unknown mineral, but thought he detected a trace of platinum. Further and larger specimens which he applied for he does not appear to have received.

"*Bankura District.*—Gold is reported to have been obtained in very mall quantities in the sands of the Dalkissur at Bankura, and the statement is not improbably correct.

"The absence of any record as to the occurrence of gold in the districts comprised in the Bhagulpore Division is very remarkable, as *primâ facie* the character of the geology in several of them would justify one in suspecting its presence.

"*Chutia Nagpur Province.*—The Chutia Nagpur Province includes the greater portion of the hilly region on the south-west frontier of Bengal. It is subdivided into the following four British districts and seven Tributary States: Hazaribagh, Manbhum, Singhbhum, Lohardaga: Bonai, Chang-Bhakar, Gangpur, Jashpur, Korea, Sirguja, and Udepur. From the characters of the rocks found in each of these subdivisions respectively it is not improbable that gold occurs in all of them. Whether because it is less abundant in some, as is probable, or because it has never been properly searched for, the fact is certain that in others there is a greater attraction for the indigenous gold-seekers. Judged by this standard, which is the only one at present available, the richest tracts are situated in Manbhum, Singhbhum, Gangpur, Jashpur, and Udaipur.

"That these, or some of them, may yet be the scene of extensive operations, should the gold-mining in Southern India be successful is very

possible. The indications afforded by the alluvial deposits, of sources of gold existing in the rocks over several large areas, are perhaps quite as striking in their way as those which have led to the starting of the gold-mining industry in Southern India. Quartz or reef-mining and crushing, however, can scarcely be said to have been tried in this area, but one solitary and not very extensive attempt having been made.

"*Hazaribagh District.*—There does not appear to be any published record of gold having been found in this area and properly speaking it ought not to be included in this list. But it is impossibl not to believe that properly conducted operations would reveal its presence.

"*Lohardaga District.*—The Kanchi river, in Lohardaga, contains gold-bearing sands, which are derived probably from the same series of rock as those included in the adjoining auriferous tract of Manbhum and Singbhum. There are reports of gold having been found in the Sone river on the frontiers of the Palamow subdivision, but there are no published notices on the subject.

"*Bonai State.*—Bonai town Lat. 21° 49'; Long. 85° 1'—As already mentioned gold occurs, and is washed for in the bed of the Brahmini in Bonai.

"*Gangpur State.*—Within the limits of this State gold-washing takes place in the bed of the Ebe, and in those of some of its tributaries, more particularly in the Icha, as is indicated on the Topographical Survey Map; Lat. 22° 6' 30"; Long. 83" 55' 30." This gold-bearing region adjoins those next described in Jashpur and Udepur.

"Surgeon Breton, in his paper quoted already, in reference to the diamonds of this region, states that there were gold mines in Gangpur and Jashpur just large enough for a man to descend, but of considerable extent below. In the Gangpur mine, an account of which was to be submitted, large pieces of pure gold were stated to have been found.

"There is no record of any gold-washing being carried on in Korea and Chang-Bhakar States, and although gold is enumerated in a list of the products of Sirguja by Colonel Ouseley, it is not sought for there at present.

"*Jashpur State.*—Colonel Ouseley, when forwarding to the Government specimens of gold for assay, specifically mentions the village of Phar-

sabahal as the locality from whence they were derived. Other authorities are less precise, and indeed it is not quite clear whether portions of the following remarks refer to Jashpur or to Udepur.

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"*Pharsabahal.*—Lat. 22° 30'; Long. 83° 55' 33" (Atlas Sheet, 105, S.W. From this locality, which is about 4 miles to the west of the Ebe, Colonel Ouseley forwarded Rs. 11 weight of gold obtained from mines. Each village is bound to pay a certain weight of gold annually to the Raja, the heads of villages (Tikadars) buying from the Jhoias and paying for it in rice. The following reports on all the gold forwarded by Colonel Ouseley, were issued by the Mint Master, Colonel W. A Forbes:—

Quantity received			Pure Contents.			Assay.	Intrinsic produce in tolahs or new standard of goldmohur.
			Base Alloys.	Silver.	Gold.		
			In 100 parts.				
1	2	6	4·047	8·062	87·891	3⅝ Ws.	95·888
0	8	0		7·031	92·969	1¼ Bt.	101·420
10	14	0	...	12 079	88 021	3½ Ws.	96 023

Mint Register No.	Description.	Tale	Weight in tolahs.			Assay	Assay produce in gold mohurs.		
1847. 27th August, 545	A gold ingot from gold lumps and dust.	..	12	0	3	1¼ Rs. Goldmohurs	12 12 —	4 4 —	4 4 —
			12	0	3	Co's Rs.	181	or 1	0

"A few years ago the Geological Survey Museum received from Colonel Dalton a nugget which was obtained in Jashpur. It weighed on receipt 221·87 grains, and after cleaning, 199·6 grains. On assay 13·562 grains gave—

Gold chloride	...	12·836	= per cent.	Gold	... 94·64
Silver ,,	...	0·93		Silver	... 5·15
					99·79

"The specific gravity was 15·24. The facts just given and those mentioned below, with reference to the States of Gangpur and Udepur,

establish beyond a possibility of doubt the existence of an ancient alluvial gold-bearing deposit at intervals throughout a tract not far short of 2,000 square miles in area. A considerable portion of this are a is hilly, the rocks, so far as they are known, belonging to the metamorphic series; but since there is evidence that diamonds have been found in the Ebe river, it may be that an outlier of the Vindhyan series exists there. To the west and south of this highland tract there are Gondwana rocks, including the coal measures of the extensive Raigarh and Hingir field; outliers of the Deccan trap occur to the north-east. The principal rivers of this tract are the Mand and Ebe, with numerous tributaries. As there is always water in the Ebe, it is possible that some system of hydraulic mining might be applicable. Be that as it may, there cannot but be gold-bearing reefs from which all this gold has been derived.

"*Udepur State.*—Rabkob, Lat. 25° 28′ 30″; Long. 83° 17′ (Atlas Sheet, 105, S. W.)—Rabkob is the chief town of the State of Udepur. Some of the early accounts of the washings and the assays of gold from them do not very clearly distinguish between those of Rabkob and Jashpur, which are separated from one another by about 40 miles.

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"The other localities in Udepur mentioned by Colonel Ouseley as being gold-producing are—

Kamhar, on the Korija river,	Lat. 22° 35′;	Long. 83° 18′ 15″	Atlas Sheet, 150 S. W.
Bairagi, on the Sangul river	Lat. 22° 42′ 15″;	Long. 83° 21′ 30″	
Salka, on the Sangul river	Lat. 22° 43′ 20″;	Long. 83° 22′ 30″	
Khandraja, on the Sangul river	Lat. 22° 43′ 43″;	Long. 83° 26′ 30″	
Bakaruma, on the Bharari river,	Lat. 22° 31′ 45″;	Long. 83° 29′	
Jamargi, on the Maini river,	Lat. 22° 34′ 30″;	Long. 83° 48′	

Mr. Ball's Memoir on *The Geology of Manbhum and Singhbhum*, is, as its name implies, a geological work: but as usual, in such publications, there are economic chapters, in which gold, as well as other minerals and stones are treated of; while throughout the body of the book there are passages important to the present discussion.

In describing the geology of Manbhum, and the lithology of the sub-metamorphic or transition series in particular, he writes:—

"The following account is intended to fulfil the part of a guide to the Geology of Manbhum rather than that of a complete description of the geological formations which occur in the district.

"The metamorphic and sub-metamorphic rocks to which these pages more particularly refer—the coal and associated formations having been already described—pass across the boundaries of Manbhum, on the north into Birbhum and Hazaribagh, on the west and south into Lohardaga and Singhbhum, and on the east into Bankura and Midnapur.

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"The geological examination of the metamorphic rocks of Manbhum was carried out from time to time, as the maps of the Revenue Survey became available, between the years 1862 and 1868. The northern portion was examined by the late Mr. W. L. Willson; the neighbourhood of the Jharia coal-field by Mr. Fedden, and the remainder by the late Mr. Ormsby and myself.

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Area. "The total area of Manbhum, as determined by the Revenue Survey, is 5,551 square miles.

"In its western and southern portions it is very hilly, and continuously

Hills. so for many miles; but to the east and north-east, the hills are for the most part quite isolated from one another and rise abruptly from the plains. The highest hill in the dis-

Dulma trict is Dulma 3,050 feet or (1,430 feet lower than Parisnath). The other principal hills are Tundi, Panchet, Beharinath, Susinia, 1,440, Gurguburu, 2,220, Raghunathpur, Tilbani, 1,336, besides many others towards the west and south.

"In the neighbourhood of Bhagmundi there is a plateau with an ele-

Bhagmundi plateau. vation of from 1,200 to 1,400 feet above the sea, which occupies an area of about 90 square miles.

South boundary ranges. "On the south Manbhum is separated from Singhbhum by a formidable natural boundary formed of several ranges of hills which are traversed by a few gorges.

"The drainage of Manbhum is effected by four principal rivers with their tributaries, and the area is consequently divisible into as many rain basins. These rivers are the Damuda, Dalkisar, Kosai, and Subarnarekha, all of which pursue independent courses till they fall either into the Hugli or the sea. The Damuda rises in Hazaribagh, the Kosai, and Dalkisar, within the limits of Manbhum, and the Subarnarekha in Lohardaga close to the station of Ranchi.

Principal rivers.

Sources.

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"The Dalkisar passes out of Manbhum close to the civil station of Bankura; its course to that point runs for from 35 to 40 miles. As a general rule, it affords indifferent sections of the underlying rocks, the reaches being, for the most part, filled with sand and clay.

Dalkisar.

"The Kosai, on the other hand, gives, especially in the higher rocks, some very fine sections of the slates, quartzites, &c. Its course in Manbhum strikes across the district from north-west to south-east for upwards of 100 miles.

Kosai.

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"The Subarnarekha crosses the south-west corner of Manbhum, cutting off the pargana of Patkum. This river has long been justly renowned for the great beauty of its scenery. On the borders of Hazaribagh it forms a cascade called Hundru Gag, which is said to be 320 feet high. In the lower parts of Manbhum, especially where it traverses the sub-metamorphic rocks, it abounds in bold and striking views, many of which illustrate, in a very beautiful manner, the effects of river denudation, as we shall have to notice again further on. Its name, *Subarnarekha*, or Golden-streaked, is derived from the fact of gold being found in its bed.

Subarnarekha.

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"*Sub-metamorphic or Transition Series*"—The term, *sub*-metamorphic has been adopted by the Geological Survey of India as a convenient name for a series of rocks which, while as a general rule, showing distinct signs of metamorphism, do so in a much less degree than do the gneissose or metamorphic rocks proper. The prefix *sub* refers then to the amount of meta-

Origin of term sub-metamorphic.

morphism, not, as might be supposed, to the position in the geological scale.

"In different parts of India, where rocks of this character occur, various local names have been adopted: it yet remains to be seen how far they can be safely correlated with one another, and with similar series of other countries.

Other names.

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"In Manbhum the principal area oocupied by the sub-metamorphic rocks is situated in the southern half of the district. On the north it is bounded by a fault which is distinctly marked, and has been traced from the borders of the alluvium near Belaidiha westwards to a point beyond Bandgaon in Lohardaga, or for a distance of rather more than 100 miles. Southwards from Manbhum the area extends into Singhbhum, where the sub-metamorphic rocks surround or cloak an area of metamorphic rocks, the boundary being for the most part natural.

Principal area.

Extension in Singhbhum.

"In their western extension these rocks have been traced continuously as far as Raiboga in Gangpur, so that it is only a small portion of the whole area occupied by the series in Chutia Nagpúr which is included in the district of Manbhum.

Extension westwards.

"Besides being found in this main area, the sub-metamorphic rocks exist also in smaller outlying tracts resting on the older metamorphic rocks. The principal of these are situated near Supur and Manbazaar, where the rocks are much cut up by faults, to the local subsidences in connection with which their preservation is probably due. At more distant localities there also occur rocks which lithologically resemble some of the principal forms of the sub-metamorphics, but some of these exist as bands in the older rocks, and are quite inseparable from them.

Detached areas.

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"So far as the rocks of this series have been examined, they appear to be azoic. They consist of quartzites, quartzitic sandstones, slates of various kinds, shales, hornblendic, mica, talcose and choloritic schists, the latter passing into potstones, and interstratified greenstones or diorites with trappean ashes. In adjoining areas limestones and calcareous schists, containing actinolite, tremolite

Limestones occur in adjoining areas.

or other adventitious minerals, occur also in this series, but have not yet been met with in Manbhum.

"The presence of beautifully preserved ripple-marks in the slates and shales shows that the metamorphism has not been of a very complete or uniform character. Were it not for the quartz veins, which traverse them, some of the green shales are so little affected by metamorphism that they might be mistaken for Talchirs.

Ripple-marks.

* * * * * *

"As compared with the rocks of the metamorphic series, these are rich in ores and metals, the following having been found in Manbhum: gold, copper, argentiferous galena and iron.

Rich in metals and ores.

"As has already been stated, the physical features characterising the areas occupied by the sub-metamorphic rocks are very different from those prevailing in the metamorphic tracts. In the former, the harder varieties of rocks form ranges of hills which strike with the bedding, and in most instances the beds persist with the same thicknesses and relative position to those on either side of them, for very considerable distances.

Physical features.

"The succession of the hill-formers is best seen in the neighbourhood of the Subarnarekha, where the peculiar characteristics of each is well represented. Most northern is a cherty quartzite which rises into saddle-shaped hummocks, then follow two chains of truncated or perfectly conical hills formed of slate, then a massive range of irregular elevation, composed of intrusive trap, whose highest part forms the fine hill called Dulma.

Hill-formers.

"South of it there are two ranges, one of granulit or felspathic quartzite, and the other of talcose and micaceous schists of tolerably equable elevations throughout. As mentioned above, they are traversed at intervals by gorges which have been produced by river cutting operating from above.

"Before proceeding to the detailed description of this area, it will be well to discuss two subjects which are intimately connected with its physical features. These are the faulted character of the northern boundary and the intrusive origin of the great trap dyke which, as just alluded to, forms Dulma hill.

"*Faults and Dykes.*—In the alluvium on the East, close to Belaidiha, the position of the boundary is indicated by a ridge of pseudomorphic quartz, which, as we shall presently show, accompanies it at intervals for many miles. A little further west, off the alluvium, where the rocks are reached, there is abundant evidence of disturbance, and the rocks on either side dip away from the line of fracture. This line of fracture, as not uncommonly occurs, soon shows itself to have become, by means of infiltration, the receptacle of various ores, but principally of those of iron. In many places iron has been replaced by quartz, some of the pseudomorphic plates of which show the delicate etching which occurs on specular or micaceous iron, while in other cases the iron has not been completely removed, but is retained in the interstices. Occasionally the quartz pseudomorps are after gypsum or barytes Sometimes the quartz occurs massive, but penetrated by numerous intersecting veins.

Pseudomorphic quartz.

Etched surface of quartz.

"Near the village of Barabun, further to the west, there is a run of this fault rock, and at the Pora hill both fault rock and brown hæmatite occur. Close by, the fault cuts off a small area of sub-metamorphic rocks from the main tract and north and north-east of Ambikanagar, the line of crush is again marked by lodes of hæmatite, which appear to contain a great abundance of rich ore. From this for 6 miles further west, save in the contrast of the rocks on either side, there is no surface evidence of the exact line of the fault. But in the hills between Bulrampur and Bauch there is another strong deposit of hæmatite, beyond which and on the same disturbed line there is an old worked out copper-mine in which traces of malachite and azurite are still to be found as encrustation on the neighbouring rocks. In its vicinity there is a vein of coarse crystalline dolomitic limestone.

Hæmatite along fault.

Copper mine.

Limestone.

"A little further west there is another large outcrop of hæmatite which was erroneoulsy marked *coal*, on the oirginal Revenue Survey map. After this the fault again cuts off a narrow strip of sub-metamorphic rocks from the main area. Its position from hence westwards is marked by a range of hills 250 to 300

Hæmatite is marked *coal* on map.

feet high, which are formed of pseudomorphic quartz of similar character to that above described. They strike to 25° north of west, and continue for a distance of about 10 miles. North of Barabazar, a branch fault coming from due east joins the main one, which then pursues a slightly north of west course, and can be easily traced by exposures of fault rock and faulted junctions for a distance of 18 miles. South of Dabah there is a range of hills similar to those just mentioned, and formed exclusively of the pseudomorphic quartz. West from Dabah the position is marked by veins of brown hæmatite. Close to Janum a cross fault has flung the main fault somewhat out of direction, beyond which a low ridge of pseudomorphic quartz marks its position up to the Subarnarekha, in the section in which river its effects are apparent. West of the Subarnarekha and Patkum it has been traced for many miles beyond our area into the Lohardaga district.

Range of hills marking position of fault.

Cross fault.

Western extension of main fault.

"*The Dalma Trap.*—"Traversing the sub-metamorphic rocks from east to west there is a run of trap of very unequal dimensions, as it varies in width from about ⅛th of a mile up to nearly 3 miles. Sometimes it bifurcates, its branches having broken through the bedding of the surrounding rocks.

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"In reference to the surrounding rocks this trap occurs in a trough, the beds on either side dipping towards it; but since there is no repetition—the beds on the immediate north being slates and quartzites and those on the south schists and granulit—it is clear that at the base of the synclinal trough there must be a dislocation of the strata, and it would appear that it was along this line that the molten matter was thrust up. Other independent evidence of a crush-up occurring here is furnished by the existence of lodes of hæmatite along the northern edge of the trap, which are precisely similar to those occurring on the great fault. Tracing this dyke from east to west, it presents the following appearances :—

Synclinal.

"South of Dhadka, near Rajgaon, it is very much broken up, as it also is in Midnapur. About 2 miles west of Dhadka it commences a steady course, which

Course of the trap.

continues unbroken up to the Subarnarekha, and is thence continued many miles into Lohardaga. South of Dusra there is a bend in the direction of the dyke which is not shared in by the surrounding rocks, as they preserve a steady strike.

"North of Asanbuni the southern flank of Dulma is, for the most part, obscured by a talus of trap boulders. Ascending the hill the same trap is seen *in situ* until the first ledge is reached, where, in the bed of a stream, there is an indurated chloritic rock exposed. At various points throughout the dyke, bands or included masses of this rock occur. Several opinions as to their origin might be offered :

Section.

"*1st.*—They are portions of the trap itself, characterised by the segregation of chloritic minerals or their local production by alteration.

"*2nd.*—They are detached masses of original rock carried up from below.

Origin of chloritic enclosures.

"*3rd.*—They are schists *in situ*, which are merely enveloped by the intruding trap.

"The first might possibly be the true explanation, as such cases are not unknown ; at the same time the rock closely resembles in lithological character some of those which occur interbedded in the sub-metamorphic series, so it is more probable that the 2nd or 3rd alternatives, or both, afford the true explanations.

"Above this there is trap again until the summit is reached. The trap of the summit and main axis of the hill is a decided *breccia*, while that of the lower portions is compact or amygdaloidal.

"The section across the dyke north of Ramgarh is somewhat different from that just given—It is

Section north of Ramgarh.

1. Indurated chloritic schist.
2. Porphyritic trap.
3. Indurated chloritic schist.
4. Compact and amygdaloidal traps.
5. Indurated chloritic schist.
6. Brecciated trap.
7. Indurated chloritic schist.
8. Brecciated trap.

"The brecciated trap is well seen in the bed of the Subarnarekha north of Kutia. It is possible that the brecciated appearance may be due to segregation; but it is more probable that the contained masses are fragments of an original outburst, which have been taken up again and partially reconsolidated by a more recent one.

Breccia.

"Hornblendic rocks occur in the formation, which, if they are of igneous origin, were probably contemporaneous; but being interbedded, a doubt must always exist as to their true character.

Interbedded traps.

"The south boundary of the sub-metamorphic area crosses the Kosa river near a village called Guriada, whence it stretches westwards to Kuliapal, round which it bends to south. This boundary passes through dense jungle, and was traced with great difficulty.

South boundary.

"South-west of Shamsunderpur and Phulkusma there is a considerable outlier of the younger rocks which is separated from the main mass by a zone of rocks of somewhat indefinite character. So far as seen, they consist chiefly of vein quartz with a few outcrops of schists. Towards Raipur on the east, and Kuliapal on the west, however, they are associated with granitic rocks, so that little doubt can exist as to their true affinities.

Outlier.

"This outlier occupies an area of about 16 square miles. On the south it is continued for a short distance into Midnapur. A good section of the rocks is exposed in the river north of Phulkusma. Close to the village of Mutguda there are some pits in the potstones, and plates are manufactured from them to a small extent.

Outlier.

In the Narsinghpur Ghat, which is traversed by the Gurum river, there is a very clear section of the rocks which form the ranges of hills separating Manbhum from Singhbhum. A succession of gorges, generally from 1½ to 2 miles distant

Section in Narsingpur Ghat.

from one another, enable the same beds to be traced for about 60 miles. The principal varieties are—

Slates.
Felspathic quartzites or granulit.
Talcose and micaceous schists.

"Towards the north boundary the best sections of the rocks are exposed in the Kosai near Gopalpur and Ambikanagar, where they consist chiefly of talcose schists, potstones, hornblendic schists, and bluish quartzites.

Sections in Kosai.

"At Bangorda, in Barabhum, there is trap-like rock which forms a range of bare red hills The colour is due to the weathering out and decomposition of magnetic iron, and the detritus from it is almost identical with one common variety of laterite

Trap-like rock.

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"The Subarnarekha from the borders of Dhalbhum to the boundary fault affords a section which is given here for the purpose of enabling comparison to be made with similar rocks in other parts of India—

1. Mica schist.

Interval concealed.

2. Mica schist.
3. Quartzite sandstone.
4. Fine gneiss.
5. Mica schist.
6. Granulit.
7. Quartzite.
8. Hornblendic.

Dip 25° north-north-east.

Interval concealed.

9. Hornblendic.
10. Potstone (indurated chloritic schists).
11. Hornblendic (Trap?).
12. Potstone.
13. Quartzite.
14. Sandy talcose schist.
15. Potstone.
16. Hornblendic.
17. Quartzite with mica.
18. Talcose schist.
19. Mica schist.

Dip 60°-70° north-north-east.

Dip 60°-70° north-north-east.

20. Felspathic quartzite or granulit.
21. Potstone.
22. Grey and green argillaceous slates.
23. Hornblendic.
24. Flaggy talcose slate.
25. Talcose schists and impure potstones.
26. Slates.
27. Quartzite and granulit.
28. Trap (Dulma).

Interval.

29. Ferruginous schist.

Fault.

Dip 70°-80° south.

30. Quartz with brown hæmatite.
31. Blue, green, and grey slates.
32. Black carbonaceous-looking slates.
33. Blue slates.

Interval.

34. Green slates.

Interval.

35. Blue and green slates.
36. Blue slates.
37. Quartzite and blue slates.
38. Phyllite and quartzite.

Dip south.

39. Shales and phyllite.
40. Quartzite.
41. Potstone.
42. Slates.
43. Talchir-like shales.
44. Quartzite.
45. Hornblendic (Trap ?)
46. Quartzite.
47. Potstone.
48. Quartzite.
49. Coarse hornblendic (Trap ?
50. Potstone.
51. Quartzite.
52. Potstone.
53. Hornblendic.

Dip south.
54. Coarse horblendic (Trap ?)
55. Fine gneiss.
56. Potstone.

Dip south 30°.
57. Hornblendic (Trap ?).
58. Potstone.
59. Hornblendic.
60. Potstone.
61. Shales.
62. Blue quartzite and phyllite.
63. Green and mottled grey shales.
64. Quartzite with veins of quartz.
65. Shales.

Fault.

Granitic gneissose rocks and schists.

"The above, it must be remembered, is a section of the rocks seen in the Subarnarekha, and is not intended to be taken as a complete section of the rocks of the formation. Up to No. 27 the general dip is northwards, and from that it is southwards, although no distinct repetition can be made on either side of the trap and its accompanying fault.

"*Outlying areas of sub-metamorphic rocks.*—North of the main fault, in the vicinity of Supur and Manbazar, there are a few outlying areas of sub-metamorphic rocks which appear to owe their preservation principally to a series of cross faults which have let them down into the older rocks. These faults are all well marked, the edges of the different formations being in some places in abrupt contact and in others only separated by ridges of pseudomorphic quartz or lodes of brown hæmatite. The rocks occurring in these areas are chiefly alternations of quartzites, potstones, and hornblendics corresponding to the lowest part of the section given above It would be tedious and unnecessary to repeat all the field-note-book details of these areas. All the information likely to be required concerning them is contained in the original field maps on the scale of 1 inch = 1 mile. As in the main area, the superficial deposits are in these also more or less auriferous.

Cross faults.

Auriferous deposits.

"In the northern parts of Manbhum there are, in several places, rocks which bear resemblance to the sub-metamorphics but which possibly only exist as bands in the

Doubtful sub-metamorphics.

older rocks. Of such cases the least doubtful is that of the rocks forming Sasunia hill, well known in the district as the locality in which the so-called Bardwan paving stone is obtained.

Sasunia Hill.

* * * * * *

"A rough calculation makes the thicknesses of these beds to be about 360 feet. I was unable to trace them in the section either on the east or west, and I am therefore inclined to believe that they are unconformable to the gneiss series, and exist as an outlier from the sub-metamorphics series, to the rocks of a zone in which they present a lithological resemblance.

Thickness.

"North of Jaipur, in the Gardia hill station and its neighbourhood, there are some quartzites very like the sub-metamorphics, but which appear to be interbedded with gneiss, such as never occurs in the sub-metamorphics. The continuation of these rocks in the Lohardaga District was noted by the late Mr. Ormsby, who describes them as being very like the sub-metamorphics, but he did not attempt to map them as separable from the metamorphics.

Gardia Hill.

Continuation in the Lohardaga District.

"Towards the north-west of the area and passing into Hazaribagh, Mr. Willson observed some quartzites and chloritic schists intercalated with the gneissose rocks. In Hazaribagh, north of Barhi, there is a strip of slates and quartzites considered to be identical with the transition rocks of the Rajgir hills to the north.

* * * * * *

The district of Singhbhum is politically divided into the Kolhan or Hodesum, which is inhabited by the Hos or Larka Kols; and Singhbhum proper which contains the estates of the semi-independent chieftains of Saraikala, Kharsawan and that of the former Porahat chief, who forfeited his territory for misconduct in 1857. To the north-east the pargana of Dhalbhum is situated; it separates Singhbhum from Manbhum and Midnapur. Its chief is also semi-independent.

Political divisions.

"The examination of the part of Singhbhum included in the present map, was accomplished in the season 1868-69, with the exception of a small portion to the west

When examined.

of Chaibassa, which could not be completed then on account of sickness. An opportunity for doing so occurred in 1874-75, when the writer was marching to examine the Raigarh and Hingir coal-field in Gangpur and Sambalpur. This served to square up the tract to about the 22° 30′ parallel of north latitude, south of which, except in the valley of the Subarnarekha, up to the present, no geological survey has been made. In the year 1870 a brief sketch of the geology, in connection with a detailed account and map of the copper-bearing rocks, was published; but the present more complete account was kept back awaiting the time when the remainder of Singhbhum and some of the adjoining districts south of the 22° 30′ parallel could be examined and the results incorporated.

* * * * * *

"The district of Singhbhum, though imperfectly known to the general public, has been more frequently examined geologically than many more accessible and important localities in India.

"It often happens in this country that the geological surveyor has to examine a district unaided by a single trustworthy observation made by a local observer, so that it is with much gratitude I record the assistance which I have received from the published geological notices of Singhbhum.

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"On the north-west, Singhbhum is bounded by a portion of the Lohardaga or Chutia Nagpur plateau, from which there is a somewhat steep descent into the low-lying plains of Singhbhum. The various routes, one of them being a made road, traverse the spurs with intervening valleys into which the plateau becomes here broken up. The extension of two of these spurs is marked by hill ranges, which continue for a distance of about 70 miles to the south-east, after which they gradually break up, the rocks forming them, finally disappearing under the alluvium of Midnapur.

Northern Spur and Range.

"The more northern of these prolongations of the spurs, if they may so be called, has been already alluded to in the foregoing description of Manbhum. It may be well here, however, to indicate its leading structural features throughout. It is made up of three subordinate ranges, which are separated by well-marked valleys where the softer rocks have been eroded away. These ranges are formed respectively of trap, quartzite and schist. The hills

Trap. formed of the trap range attain the highest elevations, its principal peaks, west of the Subarnarekha, being Chatwa 2,673, Bicha 2,776, Tatkora 2,910, Nanji 2,491, Kirda 2,772, Pandu 2,778, Desan 2,760, Sindurhuli 2,924, Jojo 2,836, Sawai 2,331, Girgirali 2,529. Besides these there are a number of other peaks upwards of 2,000 feet high. As the valley of the Subarnarekha is approached, there is a somewhat gradual descent till the hill marked H. T. 185 is reached, after which there is an abrupt descent to the level of the bed of the river.

"East of the Subarnarekha, a gradual rise attains, within 11 miles, to the highest elevation—Dulma—3,050 feet. Thence eastwards, the elevation is inconsiderable. Although this range contains peaks of such varying heights, the general effect, when viewed from a distance in Manbhum, is as of a range of uniform or but little varying height. This trap has shared in the dislocation to which the rocks generally have been subjected on the borders of Midnapur and in the hilly disturbed area which lies north-west of Silda.

"South of the trap there is a range formed of quartzite, which, being in some places felspathic, might be called *granulit*. This is not very well seen west of the Subarnarekha, where it seems to thin out gradually; but east of the river it forms a continuous range, the peaks of which are from 1,000 to 1,500 feet high. In the extreme east, greater heights are attained—as in Dhargiri 1,738 feet and Lakesini 1,636 feet.

Quartzite.

"The southern range is formed of micaceous and talcose schists, both this and the preceding contrast with the trap range in being broken up by frequent gorges which occur at intervals of every few miles, such passages for the drainage being very rare in the trap range.

Schists.

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"Although these ranges are the principal components of the spur, it is not composed of them alone. On the northern there is a much broken range formed of conical hills of blue slates and some thin-bedded quartzites. North of these, too, at a short distance, there are some hills formed of quartzites and slates,

Subordinate Ranges.

and an outcrop of a remarkable chert-like quartzite, which forms a line of low hills.

Southern spur.

"The second spur leaves the plateau at a point about 9 miles south of the other, whence it pursues a steady eastern direction for a distance of 42 miles, and then sweeps round to south-east and south. Near its starting point from the plateau this spur is much broken up into small detached ranges of hills between which wide valleys intervene. Between Narangpur and Rajdoha these ranges are larger, and approximate more closely to one another; but it is only in its extension to the south-east of Rajdoha that this spur acts as a distinct water-shed.

"The principal rocks forming it are mica-schists with quartzites; but towards the south-east there are several runs of interpolated trap. The total thickness of the quartzites is much increased, too, in that direction.

"The principal peaks on this spur are Lopso 1,612 feet, Okam 1,398 feet, Dholia Chundar 1,107 feet, Sidheshar 1,477 feet, Kapargadi 1,651 feet, Kujundi 1,676 feet, Salberia (1) 1,845 feet, Salberia (2) 1,799 feet, Dalma 1,676 feet. In the schists of the northern flank of these hills the copper ores of Singhbhum and Dhalbhum occur.

"Between these two spurs there is a belt of inhospitable, sparsely populated jungle land; the soil is exceedingly poor and unproductive. It is studded with small hills which are formed principally of hornblendic schists.

Central granitic gneiss area.

"South of the second spur the granitic gneiss area of Central Singhbhum is at once entered upon. On the north, east, and west, and probably to a certain extent on the south, it is cloaked round by ranges of hills formed of the submetamorphic rocks which seem for the most part to rest naturally on the granitic rocks. This area is traversed by a net-work of trap-dykes, the most important of which form very definite ridges, one of them rising to 1,997 feet, or about 1,200 feet above the plain.

"The granitic gneiss rocks traversed by these traps being much decomposed at the surface are for the most part obscured by recent superficial deposits, but occasionally they appear through these, showing a characteristic bossy, dome-like form. To the west of this central area,

and intervening between it and the highlands of Porahat, there is a tract in which both metamorphic and sub-metamorphic rocks occur, as will be described in detail further on.

"The drainage of the western portion of the country, south of the second spur, is effected in a northerly direction by a fine river called the Korkai or Kodkai, which measures from its source to its junction with the Subarnarekha upwards of 100 miles. The direction of its course throughout is northwards, whereas the Subarnarekha runs south-eastwards, the valleys of the two rivers being separated by the second or southern spur.

Korkai river.

"The principal tributaries of the Korkai are the Ili, Raro, Sonjai, Sona, and Bongbonga.

'The eastern portion of the area is drained by a number of small rivers and streams, the principal of which are the Gurum, Gurrha, Gharmora, and Sonk.

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"*Sub-metamorphic Series.*—In the foregoing account of Manbhum the rocks of this series have been, in part, described. In Singhbhum the main area occupied by them is reached, and some recapitulation of facts already mentioned will therefore become unavoidable.

"It may be said that there are to be found in this tract examples of almost every variety of sub-metamorphic or transition rocks which are known to occur ordinarily in other countries. Dr. E. Stoehr makes the same remark, but excepts limestone. Since his time, however, limestone has been found in several localities, where it occurs as a regular member of the sub-metamorphic series. True serpentine, which had not previously been discovered, has also been met with. Besides the many varieties of schists, shales, slates, and quartzites which make up the mass of this series, there are also some rocks which afford evidence of locally intensified metamorphism: these often have an excessively crystalline structure, and are not readily distinguishable from members of the older metamorphic series.

Limestone and serpentine.

"Throughout Singhbhum, so far as it has been examined, the rocks of this series do not occur as detached outliers, but they surround isolated tracts occupied by the

No outliers.

metamorphic rocks. One apparent exception does exist in the case of the wedge-shaped tract formed of slates and quartzites which lies in the centre of the principal metamorphic area; this, however, will probably prove to be in direct continuity with the main area of the sub-metamorphic rocks to the south.

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"*Trap of the Sub-metamorphic Area.*—The great Dulma trap-dyke which has been described in the account of Manbhum was, during the examination of Singhbhum, followed in both its eastern and western extensions. On the west, south of Tamar and north of Kenke, it suddenly increases in width; this appears to a certain extent to be due to a doubling back on itself. Still further to the west it rapidly diminishes to a width of about one and a half miles. Thence it was traced into the plateau as far as Jatobera, south of Bangaon. Owing to its intimate association with greenish schistose rocks, it is often difficult to trace satisfactorily the precise position of its boundaries.

"In some places, as for example on the road between Hedingda and Rabo, this trap exhibits a sort of pseudo bedding; but the rock is nevertheless, throughout, a *bonâ fide* intrusive trap, and is not unfrequently vesicular. The highest hills in Singhbhum which range from 2,500 to 3,000 feet are all situated on this band of trap. In its eastern extension though traceable for some distance, it ultimately becomes lost in the crushed and distorted strata of Midnapur.

"To the west of Chaibassa and north of Borkela, there is a group of hills formed of a very dense trap, similar in character to portions of the Dulma dyke and probably having a similar origin. Dipping away from it there are shales and schists which appear to have sustained some local metamorphism. Unlike the Dulma outburst, which in some parts of its course runs with the strike of the rocks and is continuous for many miles, that at present under notice which may be distinguished by the name of the principal peak, as the Ongabira trap, occupies a very irregular area, the limits of which may be best understood by a reference to the map.

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Auriferous rocks.

"A considerable thickness of grey and greenish mudstones and shales is exposed in the Sanjai river near Binj. They dip at from 40° to 80° to north-west. Between the

Sanjai and Chaibassa these rocks occupy a considerable area; they are there much crushed and jointed, and quartz veins occur in some abundance, though they are not of great length or size. It seems not improbable that they contain gold, as the superficial deposits are washed for gold during the rains by the inhabitants of Binj. The section of rocks seen in the stream near Kesia recalls some of those described in gold-producing countries.

"The schists of this series are, for the most part, distributed in definite zones, seldom occurring in regular alternations with other rocks. The principal of these zones form the southern ridge of the northern range. It has already been described in the account of Manbhum. Some of the beds are talcose, in others there is a mixture of talc and mica, while the remainder are simply micaceous. The foreign minerals of commonest occurrence are andalusite, staurolite and magnetic iron. These are well seen in the rocks in the section at the Gutuhatu gorge at the foot of the Abunkapi Ghat.

"Schists occur associated with quartzites and trap-like rocks in the country between Kharsawan and the Subarnarekha. These rocks afford an example of the higher metamorphism of beds comparatively high in the series which has been alluded to above.

"In certain schists which form the northern flank of the central range, the copper ores, which will be described in the chapter on the economic resources, occur. The principal matrix is a black mica schist, with veins of quartz; but at Rajdoha there is a bluish grey schist in which copper-pyrites has been found. Of magnesian and chloritic schists there are two classes distinguished by their mode of occurrence, and possibly, too, by their origin. One is a regular member of the series, and is found with interbedded mica schists, quartzites, hornblendic rocks, &c., as the case may be, and the other occurs in very intimate connection with the Dulma trap, as has been already described in the Manbhum report. Both Dr. Voysey and Dr. Stoehr allude to the transition from the trap into the potstone.

"No analyses are available from which it might be possible to indicate innate distinctions between the rocks of the two classes. Some differences in texture may, however, be pointed out. The trappean potstones generally have either a fibrous or coarsely crystalline structure, while in those of the other class foliation may generally be discerned

on close examination; but this difference in structure is possibly a secondary result produced by the influence of the trap which has thus obliterated the foliation.

"The principal beds of magnesian schist are—

First.—In the southern ridge of the northern range or spur where it is associated with the above described micaceous and talcose schists. Several mines and quarries, particularly those of Tikri, north of Ghatsitis, are in this bed.

Second.—There is another bed which occurs in the southern range; it is worked at Dari and other points. It is remarkable for including veins of white indurated silicate of magnesia.

Third.—There is another bed of potstone in the wedge-shaped area of sub-metamorphic rocks, which lies within the limits of the central metamorphic trap-traversed tract.

Fourth.—A short distance north of Jonua, to the west of Chaibassa, there is an under-cut quarry in a magnesian schist, from which stone is extracted. It seems to be of less good quality than that obtainable elsewhere, having a very distinctly developed foliation structure.

The trappean potstones occur both within this area and in that described in the Manbhum report.

Serpentine.

"In the Chitung hill, to the west of Chaibassa, there is a trappoid-looking rock, which, on examination, proved to be an impure serpentine.

Calcareous schists.

"Highly calcareous schists occur at two principal localities, one being in the neighbourhood of Chaibassa, and the other at Songra and Kondugutu, south of Bandgaon. In the former locality the rock is a well foliated schist consisting of layers of talc and calc spar. This rock crops out close to *purana* Chaibassa on both sides of the village of Nemdih and at Kandoberá.

"The other rock has a more crystalline structure; indeed it should scarcely be classed as a schist. Instead of talc it contains actinolite. It occurs in the Harni river near Songra, and it is also seen near Lota in Kondrugutu. There is still one more form of schist to be noticed; it is one of the component rocks of the Lopso range of hills but is

apparently unrepresented elsewhere. It consists of tremolite, kyanite, and talc in association with quartz. It weathers into large rounded masses which strew the ground at the base of the hills.

"Throughout the area included between the northern and central ranges there are frequent outcrops of hornblendic greenstone-like rocks which strike with the schists. As to the origin of these rocks, there is nothing to add to what has already been said in the Manbhum report.

" 'Hornblendic rocks in other parts of the area, or in different horizons in the sections, are exceedingly rare.

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"GOLD.—In Singhbhúm gold occurs in very much the same manner as it does in Mánbhúm, the principal gold-bearing rocks being in unbroken connection throughout and forming one united tract, with this difference, that in central Singhbhum, so far as is certainly known, the sub-metamorphic rocks alone contain gold.

"In Mánbhum quartz reefs are not abundant in the sub-metamorphic rocks, and the washings seemed to point to the magnesian schists and certain bluish quartzites as being the sources of the gold. In Singhbhúm, especially to the north and west of Chaibassa, quartz reefs are abundant in some earthy shales and slates, though not continuous for long distances, and it seems probable that they may prove to contain gold. The only nugget seen by the writer in Singhbhúm was in a quartz matrix; and gold, but only in small quantities, is said to have been obtained by quartz-crushing at Landu.

"Before giving the known details regarding these localities, it may be well to describe the gold-washers and their operations, it being understood that they apply equally to those of Mánbhúm.

"The class who more particularly follows the trade of gold-washing belong to a tribe of Gonds, known as Jhoras, Dhoras, Dokras, Toras, or Jháras, according to locality. The name Jhora is said to be derived from *jhori*, a small stream; but Dhora may be derived from *dhona* to wash. In the case of these people, both sexes engage in the pursuit; but the Ghasis, a local tribe of unknown origin, also occasionally wash for gold, among them the men only, while among certain Kol or Munda tribes to the west of Singhbhúm, the women wash for gold; but their male relatives regard the work as an unworthy occupation for their sex.

"The methods employed by these different tribes appear to be identical in all essentials. Each occupies a distinct tract, and poaching on each other's favourite streams is not indulged in to any great extent.

"The wooden dish used for washing by the Jhoras measures on an average about 28 by 18 inches for the men, smaller ones being used by the women and children. The dish is hollowed somewhat eccentrically to a maximum depth of 2½ inch-s. A scraper formed of a flattened iron hook, set in a handle, serves to collect the auriferous sand and gravel which accumulates in the angles formed by the rocks in the beds.

"The dish when filled is placed in shallow water, and the operator, working with his hands, soon separates and throws aside all the coarser gravel and stones, while the agitation of the water serves to carry away all the mud and lighter portions. The dish is then balanced on the palm of the left hand and oscillated to and fro with the right; this serves to throw off the greater portion of the remaining gravel, and the process is completed by a circular motion which is communicated to the water in the hollow of the dish, by which even the smallest particles of foreign matter are separated, and the final result is a residue of black iron sand in which specks of gold are readily apparent; but as mercury is not employed in this part of the country, all the very small and invisible gold is lost.

"The daily earnings of the gold-washers are small, but might, no doubt, be increased, if it were not that they are always satisfied when enough gold has been found for procuring the day's subsistence.

"The principal places where gold has been found in Singhbhúm are as follows:—

Kamerara.—Lat. 22° 15.′ Long. 86° 43′ 30″.—According to Colonel Haughton, gold has been found in the bed of the Subarnarekha at this locality which is on the eastern margin of the rocky tract. He states his belief that the sands of this river continue to contain gold from thence to the sea.

Kapargadi Ghat.—Lat. 22° 39.′ Long. 86° 23.′—A nugget of gold shown to the writer when in Singhbhúm was said to have been found, close to the pass on the Midnapur road through the Kapargadi Hills.

Landu.—Lat. 22° 43′ 30″. Long. 86° 15′.—At Landu and various other places the copper ores were in some cases found to be slightly auriferous. A Mr. Emerson was employed by the Singhbhúm Copper Company specially to investigate the gold resources of the country. He is said to have crushed a quantity of quartz, but there is no record as to the results which he obtained.

Asantoria.—Lat. 22° 44′. Long. 85° 51′.—At Asantoria or Assuntullea, gold is said by Colonel Haughton to occur *in situ*; but it appears from the context that it is not to be understood that it was actually found in the rock there; but the locality being higher than the neighbourhood, it was concluded that the matrix was close by.

Sonapet.—Lat. 22° 53.′ Long. 85° 44′ 30.″—Sonapet or the 'mother of gold' is the valley of the Sonai river to the north-west of Kharsawan; all writers on the district refer to it as containing more gold than other parts of the district Some years before 1854, nuggets were found there according to Colonel Haughton, but the finder never divulged the secret of the exact spot.

Porahat.—Lat. 22° 36′. Long. 85° 30′.—Colonel Haughton alludes to a tradition of a regular gold mine having been driven into the side of a hill in the jungles of Porahat. No traces of this mine remain at present. Gold-washing is carried on in the streams of Porahat by the women only of the Mundá inhabitants. Dr. Hayes, late Deputy Commissioner of Singhbhúm, says that the washers make use of an infusion of the leaves of the *Atungi* tree to separate the gold from the sand. I have not been able to identify this tree.

Saranda.—In Sarandá, which is a hilly elevated tract included in Singhbhúm, and which intervenes between Singhbhum and Gangpur, gold is washed for to some extent. Its occurrence in Anandapur and at Arabhanga is recorded by Colonel Haughton. The latter name does not appear on the map, but close to Dhipa gold-washing was witnessed by the writer.

Dhipa.—Lat. 22° 26′. Long 86° 15′.—The bed of the Koel near Dhipa yields a small amount of gold. The 'pay-dirt' was scraped out from the nooks and crevices of some protruding rocks. Both sub-metamorphic and metamorphic rocks occur in this region. Colonel Haughton on

his map represents the beds of the Koel, Karo, and Sunk, and the Brahmini, which is formed by the junction of the three as gold-bearing, and they are so no doubt to some extent."

The matter of much of the foregoing quotations from Mr. Ball's Memoir may be thought irrelevant and savouring too much of geological language; but, where the source of the gold is really not known, some geological discussion is needed as a guide to the finding of that source, otherwise the prospector might as well go wandering aimlessly over the thousands of square miles of Chota Nagpore on the chance of coming across quartz reefs or something looking like quartz outcrops, which indeed is very much the style of what has been done by a crowd of poor men who, every other occupation having failed, have taken to breaking every loose bit of siliceous rock coming in their way, which they laboriously bring into Calcutta as a testimony of their mining and prospecting accomplishments.

The value indeed of such information may be illustrated by the case of the one traditional mine which up till very lately had never been found, the search for which was really instigated by a close perusal and study of the details given in Dr. Ball's Memoir. The old mine has been found, and quartz taken from it has yielded a very fair percentage of gold. We feel confident therefore that the following up of the indications given above concerning vein quartz, fault-rock, fault lines, and the associated conditions of certain kinds of the transition series must lead to more certainty as to any auriferousness of these rocks.

In this Memoir, we are at last brought face to face with actual quartz reefs, for mention of which, all the previous

literature is so remarkably barren: though even now the information is small and rather general. Dr. Ball writes that in Manbhum quartz-reefs are not abundant in the sub-metamorphic rocks; whereas in Singhbhum, especially to the north and west of Chaibassa, quartz-reefs are abundant in some earthy shales and slates, though not continuous for long distances. Nothing is known of their being auriferous; they are only presumed to be possibly so: neither are any details given as to the courses of these reefs, or whether there is any systematic distribution of them. As a matter of fact, it may be concluded that over the whole tract of country then surveyed by Mr. Ball, there are no very remarkable or distinguishable quartz-veins or reefs: but that, here and there, where he, or Mr. Ormsby, surveyed the ground in some detail, quartz-veins or reefs were met with at places. Neither time nor means were available for probing or cutting into these reefs, such as they were: and anything that was done in the way of gold search relates to the examination of auriferous sand tracts, their productiveness, and their possible source which, in the face of the apparent scarcity of quartz outcrops, was naturally attributable to general distribution through the country-rock. We really think that so far as their observations went, the geologists were justified in forming the conclusions they did: but there is undoubted room for the occurrence of reefs and lodes, even though they be small, in the great tracts of out-of-the-way country which these gentlemen only partially traversed; and which can really only be ascertained by close and detailed examination and actual preliminary mining.

Still, it is a matter of surprise, and a very abnormal condition of things, if, over so large an area of transition rocks and also to some extent over the much more extensive one of

the gneissic rocks, the gold obtained by washing should have really only been derived from a form of general distribution, and that a sparse one, throughout the country-rocks. The ordinary condition is that almost anywhere throughout the crystalline and sub-metamorphic tracts of Peninsular India, a trace at least of gold may be obtained by washing the surface soils and *débris;* but here, in Chota Nagpore, the gold is washed for and occurs in some abundance in particular tracts of superficial deposits; not merely in the sands of rivers (in which are the siftings from distant parts), but on the higher parts of low hilly tracts of no great extent, up to which the gold dust could not be carried against gravitation. In other words; we cannot avoid the conclusion that in many cases the prevalence of gold washing in particular tracts implies proximity of the gold sources within those tracts.

There being then this decided localization of gold-washing areas; all of these, with the exception of the immediate river alluvial tracts, may also to some extent, have derived their gold from the larger or smaller drainage area in which they lie. For example, the far-famed Sonapet tract is very clearly defined as to its drainage area. Any gold-sands found within that tract, except perhaps the bottom and older gravels which have not been probed as yet by deep alluvial mining, must have come from rocks, be they the country-rock or any reefs or dykes, or walls of dykes traversing that country-rock,—confined within or bounded by the water-shed of the horse-shoe-shaped line of hills girdling the valley on the north, south and west.

As with this Sonapet tract, so with all the others in which gold-bearing surface soils or *débris* exist, except in decided river

alluvial tracts: the exploration should in the main be devoted to the search for quartz-veins or reefs, which must be probed by adits or cross-cuts in order to get at their value.

Undoubtedly, some of the tracts of gold-washing do not show reefs or veins of quartz: but for all that, it must not necessarily be concluded that the source of the gold is the country-rock alone, until all conceivable modes of occurrence of gold in the matrix have been searched for and tried.

As has been already hinted at, the remaining matrices for gold are:—(1) the faces or walls of fault fissures; (2) the faces or walls, and the interior of the nondescript rock material—usually called fault-rock—which very often fills these fissures; (3) the faces or walls, and some distance inwards from the walls, of greenstone trap or dioritic dykes; (4) the faces or walls and for some distance inwards from them, of the partings between different bands or groups of the many schistose components of the transition series. Then; if all these fail, the country-rock itself.

Concerning the different groups of the transition series; it may be said that:—(1) the strongly micaceous (not talcose) schists are usually not promising for gold; (2) the chloritic and talcose (not micaceous) or magnesian (pot-stone) schists, on the other hand, may, at their contact with the traps and diorites intruded among them, carry gold in paying quantities; (3) the quartzose schists, particularly the more massive forms, such as quartzites (altered and vitrified sand-stones) are known in other parts of India to be auriferous; (4) at their contact with chloritic or talcose schists, the quartzites may be found to carry gold. Likewise; along the same lines or fissures of con-

tact, there are very often runs—not necessarily veins or reefs of quartz coursing for short distances sinuously or weaving in and out among the adjacent chloritic or talcose schists—, which runs of quartz or fault-rock may be auriferous.

We will pause for a moment at this point to impress upon some of our readers the fact that although the trade name of mica is 'talc,' yet talc and mica are two minerals as distinct as possible. Mica is elastic (that is, it will spring back on being bent) and easily divisible into thin scales or plates; talc is merely flexible, very seldom occurring in plates, oftener massive, and decidedly soapy in its feel As a rule, *mica* in quartz, or strong in schists, is to be looked on with suspicion: practically, with its golden, silvery, and other colors, it has been the arch-deceiver in the selection of quartz by the wandering would-be expert. Chloritic schists are nearer the talcose schists in that they are somewhat soapy in the feel, more shiny, but not elastic; often rather massive and rocky, and usually of dark green colors weathering brown, or even reddish. Hornblendic schists are hard black or dark-green, massive rocks with, where there is one, a glassy lustre. The hard black, somewhat glassy mineral, common enough in some granite veins, as well as in quartz-veins, called schorl and related to the hornblende, is, as a rule, not promising of gold. Trap, greenstone, or diorite, are massive amorphous, generally rather dull-surfaced, dark green, brown, or nearly black rocks; hornblende being their principal constituent. As a rule, hornblendic rocks, particularly by themselves; that is, unassociated with schists (talcose in particular) are not promising.

Perhaps it may not be asking too much of the reader, to remember that gold is malleable: the smallest particle of gold,

when extracted from the rock, can be struck with the hammer when a flattened mass will remain. None of the often very delusive semblances of gold in the form of copper or iron pyrites or mica, will stand such treatment: their shivered dust should destroy the hopes of the most credulous.

Falling back on the extracts from Mr. Ball's Memoir; the Kosai River (Kushai in our map, Kossy in the Atlas Sheet No. 114) crosses the northern outlier of transition rocks near Manbazar, and then traverses the eastern end of the main tract near Ambikanagar. At this point, it is joined by a tributary from the westward which passes, for a good part of its course, through a country of gold-washings. This drainage exposes some very fine sections of the schistose or transition series, in which the sources of the gold-sands may occur. The great river is, however, the Subharnarekha (golden-streaked): for it and its tributaries traverse by far the greater part of the transition rocks. Mr. Ball gives a general section of the rocks traversed by it: and that section is wonderfully like, in the beds it exposes, some sections of the Dhárwár series in South India. It seems inconceivable, how the numerous gold-washing tracts in the course of this river should not have, to some extent at least, derived their ore from reefs or fissure planes in the country-rocks.

The northern edge of the tract of transitions in Manbhum is a faulted one from Belaidiha to beyond Bandgaon in Lohardaga. This faulted edge is marked at intervals by fault-rock. A fractured tract of country like this is ever liable to the occurrence of infiltration material, often carrying metalliferous seams and segregations; and such is the case here. Infiltrated quartz or silica, as distinguished from the ordinary

quartzose, brecciated or broken material of the fault-rock itself, is of frequent occurrence. There is certainly some room for rock gold exploration along this edge of the transitions.

The tremendous run of trap rocks signalized by the Dulma hill, and colored green on our map, occurring in the middle of the transition, or presumably Dhárwár tract, is a feature which which would attract the attention of any explorer. It does not, however, appear to be in any particular way fretted or traversed by quartz infiltration or by fault-rock. The gold-sands marked on its location by Mr. Ball were most likely derived from the higher drainage of the Subharnarekha. Mr. Ball describes how the transitions, on the immediate northern side of this trap belt, are slates and quarzites, while schists and granulite border it on the south. Most of the gold-washing tracts in the neighbourhood of this trap belt, as marked by Mr. Ball, are on its southern side; and that gold must have come from the denuded portion of these schists and granulites, or from infiltration matrices, or fissures traversing them.

North of Asanbuni, as Dulma hill is ascended, there are at several points exposures of indurated chloritic rock, which are well worthy of close examination. The section across the dyke north of Ramgarh evidently includes beds of the transition series, caught up by, or squeezed or strangulated among the igneous rocks.

In giving such details, as they are, of the sub-metamorphics of the main area at its eastern end; Mr. Ball mentions a zone of rocks south-west of Shamsunderpur and Phulkusma, which

though of somewhat indefinite character, are very interesting because they consist chiefly of vein quartz with a few outcrops of schists. He seems, however, to think that their affinities are with the granitic rocks. All the same, they are worth further examination by those interested in developing the resources of the country.

At the Narsingpur Ghat (mentioned already in the extracts from Voysey's Diary); the slates, felspathic quartzites or granulite, talcose and micaceous schists on the south side of the trappean outburst, as it occurs in the neighbourhood of Dhadka, are interesting in connection with our remarks on the association of schists.

In writing of the rocks exposed in the Kosai river near Gopalpur and Ambikanagar; Mr. Ball mentions bluish quartzites; and in this connection we may delay for a short space over the subject of bluish quartz, which of course is to be distinguished from bluish quartzites. Although gold is really found in veins or reefs of quartz of almost any color, still the usual color is white stained with ferruginous rust. The auriferous quartz of Wainad in South India, for instance, is white quartz: but the gold-bearing quartz of the Mysore reefs is generally of a grey or bluish color. In Chota Nagpore, as far as we can learn, the quartz is usually white in color, though specimens have been placed before us which are greyish approaching a blue shade. Naturally, if as is presumed, the schists, &c., of Chota Nagpore are of the same series as the Dhárwárs, and certainly they are very like them: it might be expected, though not necessarily so, that blue quartz in Chota Nagpore might be auriferous too. As a matter of fact, color has very little to do with the auriferous-

ness of quartz: and it yet remains to be seen whether the blue or the white quartz is the better rock in this region.

The bluish quartzite mentioned by Ball is, however, an altered and vitrified sandstone, not an infiltrated product: although it might be as well that the non-occurrence of even a blue infiltrated silica in this particular part of the Kosai valley were settled. Indeed, Mr. Ball himself is not without a suspicion that this rock may be auriferous. Certainly, quartzites are cupriferous in places, and it has yet to be proved that they are not auriferous.

The second part of this Memoir is devoted to a description of the geology of Singhbhum which practically covers nearly the whole of the remainder and western portion of the tract of transition or sub-metamorphic rocks. Our remarks about the rocks of Manbhum arising out of Mr. Ball's treatment of them, are equally applicable to the western portion of the main area. It is, however, to be noted here that the extreme western boundaries given on our map are only approximate: because the country in that direction, namely, the tributary States of Bonai, Gangpur, Jashpur and Udepur have not been surveyed with any closeness except as to the boundaries of the coal-bearing formation. Thus, it is quite possible that the transition series may extend a good deal further westward than is laid down in our map, or that it may be represented by outliers in these States.

The same tale of unexplored ground applies also to all the Lohardaga country, as far as the gneissic and transitions are concerned. It is certainly one of crystalline rocks, but whether there may not be considerable tracts of the sub-

metamorphics is a question which can only be settled by future survey or exploration. There can be little doubt that the granitic belt (colored dark lake in the map) of Purulia extends far eastward into Lohardaga.

1889. Bosworth Smith, Sonapet.

The now well-known locality of Sonapet has received but scant notice from previous writers. Dr. Ball, as already quoted, writes :—

"Sonapet, or the 'Mother of Gold,' is the valley of the Sonai river to the north-west of Kharsawan. All writers on the district refer to it as containing more gold than other parts of the district. Some years before 1854, nuggets were found there according to Colonel Haughton, but the finder never divulged the secret of the exact spot."

Strange to say, this valley is not marked in Ball's map (Memoir on the Geology of Manbhum and Singhbhum) with the gold-washing sign, though this is probably owing to a *lapsus* of the engraver.

The place again came prominently into notice, in the latter part of 1888, through the finding of a piece of gold which was said to have been extracted from a reef: and eventually an examination of the region was made by Mr. Bosworth Smith, late Mineralogist to the Government of Madras. With the obliging permission of the Directors of the Syndicate which at that time was prospecting the ground, we are enabled to quote the greater part of Mr. Smith's report :—

"Report on the Sonapet Gold Field, submitted by P. Bosworth Smith, Esq., F. G. S., A. R. S. M., in July 1889.

"SITUATION.—The Sonapet gold field lies in the southern portion of the Lohardugga district of Chota Nagpur, and is close to the northern boundary of the Singhbhoom district.

"The field has an area of about 15 square miles, and occupies the valley formed by a range of jungle-clad hills, rising to heights from 2,000 to nearly 3,000 feet above sea-level. The hills form the watershed of the auriferous Sona river which rises in them This river, especially the portion in the Sonapet valley, has long been noted for its nuggets of gold, and as the chain of hills is unbroken to the north, south, and west, it follows that any alluvial gold found in the valley must proceed from the reefs in the valley and the horseshoe of hills that surround it.

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"The scenery of the field and the surrounding country is typical of schistose rocks. Long lines of green hills run in the direction of the strike of the rocks, that is, from east to west.

"These hills are very different in appearance from the bare rocky, and often fantastically-shaped hills of the gneissose area. The field geologist can tell, as the hills come into view, that he is approaching a band of stratified rock, and if he has any experience of the auriferous series of Southern India, the Dharwars, he will be at once struck with the similarity in scenic features; when the rocks themselves are examined, this resemblance is rendered still more striking.

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"The Sonapet gold field is in the centre of a band of schist rocks about 22 miles broad, measured north and south through the field. Judged by the geography of the district, as seen from the top of the Desua H. S. hill, this band stretches for a considerable distance east and west over the grey gneiss on which the schistose rocks rest unconformably.

"The gneiss, a long stretch of which was passed over between Ranchi and Tamar, is generally of a dark grey colour and is composed of quartz, white felspar, and black mica. Three sets of intrusive veins traverse the gneiss,—namely, black trap, dykes, granite veins, and white quartz-veins. The black *trap dykes* are apparently diorite; they stretch north and south across the country, seemingly passing uninterruptedly into the schistose band. There are subsidiary east and west dykes. Lithologically the *granite veins* may be divided into two series, the commoner a pegmatite granite of white quartz, pink felspar, and black mica. The felspar occurs in crystals from one to four inches long and occupies the

main bulk of the rock. The mica is rare, The rarer variety of granite is an epidote granite, a compact, non-friable rock, mainly composed of epidote and pink felspar. The white *quartz veins* are generally lenticular in shape and of no great length. The quartz contains no included mineral.

"The schistose series consists of chloritic talcose, micaceous, magnesian and argillitic schists, with occasional thin bands of quartzite; but the last is a somewhat rare rock in the locality visited. The magnesian schists which may be considered as impure soapstones, graduate into variegated clays, exhibiting a violet and yellow banding near the top of the Desua hill. The chloritic schists very often contain chyastolite, and the mica schists contain numerous crystals of magnetite and an occasional crystal of kyanite; sometimes a cross of staurolite occurs.

"As my visit to Sonapet was an exceedingly short one, the exact relations of the various members of the schistose series could not be made out. * * * * * * *
One passes from the gneiss on to the schist between Bundur and Tamar; but as the road passes over the alluvial of the river Kanchi, the line of junction was not seen. But there can be no doubt that the red hills seen about three miles to the north-west of Tamar, belong to the schistose series, and that the boundary will run close to their northern flanks. This will correspond very well with the general boundary given by Dr. Ball, namely, the parallel of north latitude 23° 5′. Passing from Tamar over the Karkari river a small detached hill to the west of the cart track shows the rocks are here dipping towards the south. After passing the valley of Longtu, we come upon several trap dykes fissuring a chlorite schist that is dipping north. This dip continues up the main hill; but on the spurs to the south we come to a chlorite schist dipping south. This rock contains in places an abundant supply of thin crystals of chyastolite.

"Passing over a mica schist down the valley of Noadih, the path proceeds up the steep hill of Desua. Up its northern flanks, the following sequence of rocks occurs: talcose argillitic schist; chlorite schist; black trap much weathered; impure soapstone, and variegated clays. The trap is here of considerable thickness, and seems to form the backbone of the long ridge of high hills of which Desua is one. There are some thin beds of quartzite and a hornstone somewhat resembling the Madura wood

opal. These rocks, except the trap, dip to the north; but passing down the south flank of Desua to the Guttuhattu valley, the rock (a mica schist) is perpendicular. In the stream gorge leading to the Sonapet valley, this mica schist is crowded with magnetic crystals in octahedrons, and occasionally there are blotches of the mineral as large as three inches long by two inches broad. Some kyanite crystals were seen in this rock and some staurolite. Passing into the Sonapet valley, we come on a chloritic schist dipping south; this changes to mica schist in the centre of the valley. South of the valley the dip is to the north, and this is continued up the boundary hills which are chlorite schist. Further than this, rocks were not examined; but the schistose series evidently continues some distance to the south, the boundary being near Kharsawan.

"In the valley of Sonapet there are three series of veins

(1)	Black trap	... Diorite
(2)	Red quartz veins	... Cross-courses.
(3)	Blue quartz veins	... Gold reefs.

"The black trap dykes are very similar to those on the gneissose area, and are probably contemporaneous.

"The red quartz veins are broad continuous veins running north and south containing in places large blocks of massive black tourmaline (schorl) with occasional ascicular crystals of the same mineral. The blue quartz veins run nearly east and west round to about 15° south of east. The stone from these reefs is weathered to a brownish colour in places, and is whitened in other places; but the stone generally is exactly similar to the blue diaphanous quartz of the Kolar Gold field.

"The red veins, which may be considered as *cross-courses*, do not seem to throw the blue reefs.

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"Shortly then, the geology of the field is this—that it lies upon a band of schist rocks amongst which chlorite schist is a prominent member, and that this band consists of a series of folds squeezed together. Running through this band there are trap dykes, quartz veins with tourmaline, and blue auriferous reefs. Comparing this with the rich gold-field of Kolar, we find that the latter is a band of schist rocks, principally chlorite, which are crushed up into folds and have trap dykes, cross

courses of quartz and tourmaline, and blue auriferous reefs. Both bands rest on grey gneiss. The auriferous veins both at Kolar and at Sonapet run with strike of the rocks.

"The Kolar band is much narrower than the one at Sonapet; but, with this exception, if we were to turn the Kolar gold field round to run east and west, we should have an exact analogy to Sonapet.

"It is very probable that when the age of the Sonapet schists has been worked out, it will be found that they are in the same series as those at Kolar; that it is to say, that they will be found to belong to the real auriferous series of Southern India on which the rich mines of Oregaum and Mysore are situated, rocks to which Mr. Bruce Foote has given the name of Dharwars.

"As before stated, there are numerous reefs of blue quartz in the Sonapet Valley, and these are certainly auriferous. The presence of the nuggets of gold in the alluvium of the stream proves that the reefs here contain gold as the boundaries of the valley form the water-shed of the Sona river, so that no gold can be carried in from elsewhere. Dr. Ball speaks of the nuggets as being encased in quartz but the nugget found by Mr. Berrill has no quartz attached. The nugget weighs nearly an ounce*, and this is far heavier than anything that was found in the South Indian gold fields.

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"The blue reefs of Sonapet run nearly east and west with the strike of the country rock; they are on the average from two to three feet wide.

"The soil under the outcrop that contains the broken-up quartz from the reefs in all cases gives good shows of gold. It must be borne in mind that generally the quartz from the surface outcrop of a reef contains very little, or generally no gold. During my surveys in Mysore and the Madras Presidency, I only found gold in surface quartz on one occasion, and then the amount was hardly over a trace. * * * * * * From Sonapet we have a surface quartz from Dholbonga village assaying a little over 3½ dwts.

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*The nugget weighs 18½ dwts.

"During my stay at Sonapet, three sets of reefs were examined :

"(1) *Chattu Hassa reefs ;* (2) *Dholbonga reefs ;* (3) *Tirildih reefs.*

"*Chattu Hassa reefs.*—These lie between Dholbonga and Rolandih, and cross the main path that traverses the valley. They run about 15° south of east, and are nearly parallel with the general direction of the branch of the Sona. It is close to those reefs that the natives wash for gold and where they state that many large nuggets are obtained. It was when digging a pit on one of these that the nugget before mentioned was found. There are then large well-defined parallel reefs, or what an English miner would call "lodes." The three reefs can be seen in a bend of the nullah east of Rolandih. In the nullah two of them are nearly three feet wide ; and the other, to judge from the "stringers" into which it is broken, will be found about three and a half feet wide where unbroken. Quartz taken from the western reef at the bottom of the steam cutting gave an assay value of very nearly 2 oz. of gold per ton.

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"The middle lode is probably the one on which the trial pit was sunk, and where the nuggets were found. The reef will certainly be over two feet in width when found in the undisturbed country rock. The assay value of quartz from this pit is 1 oz. 3½ dwts.

* * * * * *

"*Dholbonga reef.*—This runs parallel to the Chattu Hassa reefs, and might be included with them. It lies about a quarter of a mile to the west of the three reefs, and is very similar to them in appearance. *Surface* quartz from this reef gave an assay value of 3½ dwts., to the ton.

* * * * * *

"*Tirildih reefs.*—Mr. Berrill showed me a large quartz vein to the north of Tirildih, the outcrop being conspicuous in a trench cut to the stream for irrigation purposes. Quartz that was thought to come from this vein was assayed at the mint ; but it is most likely that the quartz really came from another reef east of the vein. This large vein is evidently a cross course that has been bent round slightly. The quartz is white and hungry-looking, and contains small clusters of ascicular crystals of tourmaline.

"There are other reefs near Tirildih which are much better-looking

and are evidently of the same nature as the Chattu Hassa reefs; they are of blue quartz.

* * * * * *

"These three sets of reefs have been specially mentioned; but it must not be supposed that these were by any means all that were seen. On he contrary, many others were seen in the valley within the boundaries of the property, and there are also reefs on the hills. Blue quartz is found in all the steams and dry nullahs.

* * * * * *

"All these blue reefs may be classed as *fissure veins*, and are consequently likely to hold in depth.

APPENDIX.

Assays by the Calcutta Mint of Samples of Quartz from Sonapet.

The 18th June, 1889.

Register No.	Description.	Weight of Muster. Tolas.			Assay.	Remarks.
No. 8.	S. 10 (1) ...	81	.	...	·0054	Equivalent to 3 dwts. 12·672 grains troy of pure gold per statute ton.

The 14th March, 1889.

Register No.	Description.	Weight of Muster. Tolas.			Assay.	Remarks.
No. 11.	"River bed"(2)	40	...	...	061	Equivalent to 1oz. 19 dwts, 20·48 grains of pure gold per statute ton
No. 1.	C.H. 60 feet (3)	50	..	...	·036	Equivalent to 1oz. 3 dwts., 12·48 grains troy of pure gold per statute ton.

(1) Surface quartz near Dholbonga Village.

(2) Chattu Hassa east reef. (3) Chattu Hassa middle reef.

The 12th June 1889.

Register No.	Description.	Weight of Muster. Tolas.			Assay.	Remarks.
No. 7.	"T. D." 20 (4)	111·3	...	...	·0046	Equivalent to 3 dwts. 11 grain troy of pure gold per statute ton.

This is practically the first report by a specialist on a particular gold tract in Chota Nagpore, and so is of considerable value, although it lacks what may be called quantitative proofs as to the auriferousness of the reefs in bulk. The main point is that Mr. Bosworth Smith distinguishes quartz reefs or lodes of two kinds, one set being auriferous and of a bluish colour, while the others are barren and of a white colour. He states also that quartz occurs associated with the chloritic and talcose schists with trap in the ridges enclosing the valley.

The number of quartz reefs and other quartz infiltrations is, however, very small as compared with the amount of gold reported to have been obtained from the washings in past times; hence we are strongly inclined, until indications of more reefs are found, to fall back on the view already entertained by previous observers that some considerable portion of the gold may have come from the country rocks themselves, or from their surfaces of contact with the trap intrusions.

(4) Tirildih, close to cross course.

1890 Noetling. Sonapet.

The last contribution to the auriferous conditions of the same tract is by Dr. Noetling of the Geological Survey of India (Records, Geological Survey of India, XXIII, p. 73), from which it will be seen that he is almost entirely inclined to look on the gold as having come from the transition series.

Notes on the Sonapet Gold-field; by Fritz Noetling, Ph. D.

I.—TOPOGRAPHY.

"The area to be described is situated in Chutia Nagpur, in the south-east corner of the Lohardagga district. Under present conditions it is far from any way of communication as the nearest railway line is not less than 70 miles distant from it as the crow flies. It is however stated that the Bengal-Nagpur railway will pass within 15 miles south from the Sonapet river; but it is quite certain that a considerable time will elapse before the railway line is pushed so far to the south as to be in the neighbourhood of the gold-fields. For the present the isolated situation of the gold-fields must be taken into consideration, and it must be kept in mind that every piece of machinery will have to go by the expensive land route.

"As a matter of convenience I divide the area examined by me into two parts, which will be dealt with separately. The northern part is limited by the Karkari river in the north, the district boundary in the east, the northern slope of the lofty Abunkabi hills in the south, and by a small feeder of the Karkari in the west.

"The southern part includes the Abunkabi hills and the Sonapet valley.

"(*a*) The northern area consists mostly of open country, paddy-fields for the greatest part. Isolated hills covered with jungle rise frequently abruptly from the surrounding plains. These hills can, however, only be considered as detached parts of the higher ranges to the south. The northern slope of the Abunkabi hills is steep and much intersected by numerous ravines which discharge their water in a northerly direction, so that the streams taking their origin in such ravines eventually join the

Karkari river. The country therefore slopes, very slowly, however, from the foot of the hills in a northern direction ; that is to say, towards the Karkari, which flows at some miles to the north nearly parallel with the hills. It is therefore perfectly clear that all such alluvial deposits as river-sands, etc , which are to be found within the limits above described must come from the south. All the streams running through this tract drain only that particular part of the hills which lies north of the central range. It may therefore be said that all the river-deposits, except, of course, those of the Karkari itself, came from the hill tract north of the central range ; and any gold therein found must have been derived from the same tract.

"(*b*) The southern area includes the Abunkabi hills and the Sonapet valley. The Abunkabi hills may be divided into three nearly parallel ranges. The central range, which rises to about 2[illegible]0 feet on an average, forms a kind of semi-circle open towards the [illegible]east. The northern branch extends far beyond the limits of the [illegible]xamined, while the southern branch, which is much shorter, t[illegible] abruptly in a prominent hill. The southern range, which is c[illegible]y lower, rising not more than 2,000 feet, follows closely the di[illegible] the central range along its inner side. Its northern branch, whic[illegible] ends far beyond the limits of our area, is distinctly separated fi[illegible]ntral range by a deep valley gradually widening towards the east[illegible] the central and southern parts, which are not so well separatec[illegible] form with the central range one huge mass of hills, terminating [illegible]si Tulsi hill.

"The northern range runs parallel to the nort[illegible] of the central range, with which it is connected in its eastern [illegible] flat, plateau-like depression, which, however, deepens into a nar[illegible] towards the west.

"The valley formed by the semi-circular turn o[illegible] ral range is known as the Sonapet valley ; it is of a peculiar basir[illegible]e, the hills sloping towards its centre from every side except fr[illegible]st where it has an outlet. The southern hill ranges come, howev[illegible] o close up to their northern part as to form a comparatively n[illegible]te of not more than 1¾ miles in breadth, through which the Son[illegible]. The valley, as thus defined, has an extreme length of 7½ [illegible] greatest breadth being 3 miles ; as it narrows, however, conside[illegible]its upper

part, its total area can only be taken as 16·6 square miles, of which 1·3 square miles belong to the Singhbhoom district.

"The main drainage is represented by the Sona stream flowing in the longitudinal axis of the valley in an east-south-east direction. The Sona receives its feeders from north, west, and south; but it must be particularly mentioned that its main feeders are two streams coming from the north, which take their origin between the central and the southern range, and, after cutting narrow ravines through the last one, deposit their detritus in front of them in the Sonapet valley. The western feeders of the Sona are far less considerable, and from the south only a few insignificant streams discharge their water into it. Taken all in all the upper part of the Sona, of 7½ miles in length, drains a total area of not less than 50 square miles of hilly and jungly country, which is quite sufficient to provide for a large supply of water all the year round.

"From this description it will be seen that all the gold as far as it is found in the alluvial deposits of the Sonapet valley must be traced to strata within the area bounded by the central range, and must therefore come from reefs, or from the disintegration of the country rocks.

II.—GEOLOGY.

(*a*) *General Geology.*

"The strata developed in the country just described belong to the gneissic, transition, and alluvial formations; the latter is, however, only the result of the disintegration of the first one, covering it in the shape of red clays nearly all over the country, while in the shape of river-sands it is only developed in the valleys. The two groups thus given may therefore be considered separately.

1. The gneissic formation.

"The rocks belonging to this formation exhibit no peculiarity worth mentioning. They are well displayed in the northern area, and it is highly probable that they occur again in the Sonapet valley, and also on the southern [illegible] the southern hill range. As they are, however, evidently of no [illegible] for practical purposes, they may only be mentioned here.

2. T[illegible]

"This includes various schists, of which chloritic schist, mica schist, hornblende schist, and hornblende rocks are the principal. These rocks are mostly of dark green, bluish green, and dark blue, almost black colour, which makes them very conspicuous wherever they outcrop. They have evidently been much altered by great pressure, and it is not uncommon to find schists which have assumed a highly trappoid appearance, as may be seen in the instance of the Parasi hill. My time was, however, too limited to enable me to study the structure of the metamorphic rocks and their connection with the gneissic formation in detail. But from what I have seen, I believe they form two main folds represented by the northern and southern branch of the main hill ranges, which are enfolded in the gneissic formation in such a way that the latter appears again between the two ranges.

"In their various states of development the transition rocks form the main hill ranges, as described in Part I of this paper.

"In close connection with and cutting through these rocks are veins, of which two groups may be distinguished.

"The first group represents dykes, probably of diorite ; the second quartz veins. The diorite dykes are less numerous than the quartz veins ; these, however, cut through the schists in every direction. I could not, however, ascertain whether one direction is prevailing.

"There are two different varieties of quartz ; the first and more common one is amorphous of a perfectly white colour and not honeycombed. It may be met with everywhere in the area of the metamorphic rocks and is very common amongst the pebbles of the river-gravels. The second variety is crystalline, and looks like a breccia, as it consists of numerous single crystals cemented together in the same direction,—that is to say, with their prismatic sides, the shape of the single crystals, however, being much deformed. A piece of such quartz affords therefore a highly characteristic appearance which cannot be mistaken. The quartz is semi-lucid, of brown or reddish-brown colour, the lines of junction between the single crystals being sometimes filled out with a red stuff, probably hydroxide of iron. This quartz is honeycombed, and contains frequently a black mineral, probably tourmaline.

"This variety I only noticed in the Sonapet valley near the village of

Roladih : as, however, it was nearly perfectly concealed by *débris*, I am unable to say whether it forms a regular vein, or only a lenticular-shaped mass imbedded in the surrounding strata. It is also an open question whether it belongs to the transition or gneissic formation ; I feel, however, inclined to adopt the latter view.

"In neither variety of quartz could I find gold ; and unless further discoveries prove the actual existence of gold-bearing quartz, the question of the existence of such reefs must remain doubtful. At any rate, the present examinations have not yielded such information as to prove the existence of auriferous reefs.

"3. *The alluvial deposits.*—The alluvial deposits, which are more or less developed all over the country, are of two different kinds : different as regards the way in which they have been formed, different also as to their appearance. They are the following ones :—

(*a*) Red clay, including laterite.
(*b*) River sands and gravels.

"(*a*) *Red clay.*—The red clay is the result of the superficial disintegration of chiefly the gneissic formation. I do not doubt that the disintegration of the transition rocks will result in a similar product, but the typical red clay is only well seen there where the gneissic formation is to be found underneath. The red clay is rather tough, of dark-red colour, and contains a high percentage of iron, which is frequently concentrated in small irregular nodules ; it is frequently noticed that these nodules are cemented together while the clay has been washed off, with the final result of forming a bed of laterite, as for instance south of Tamar. If washed, the red clay leaves a black, heavy fine-grained sand, in which occasionally a small show of gold may be found. The red clay is well developed in the northern plains ; it is also to some degree found in the Sonapet valley, where the iron ore from it has formerly been used for smelting purposes. My conclusion concerning the presence of the gneissic formation in the Sonapet valley is chiefly drawn from the existence of the red clay therein deposited. The red clay is much less developed in the hill ranges, although it may be seen here and there.

"(*b*) *River sands and gravels.*—The river sands and gravels are especially found in the valleys in various grades of coarseness. They

chiefly consist of the *débris* of siliceous schists and hornblende rocks, with numerous fragments of white quartz. The finest sand is perfectly black, owing to a large percentage of magnetite iron or titanite ; such sand resembles perfectly that obtained by washing the red clay ; it may be considered as the special gold-bearing sand. Sand of this quality is particularly noticed in the valley, between the central and southern range north of the Sonapet valley ; it is also noticed in all the small water-courses traversing the Sonapet valley.

(*b*) *Practical Geology : The gold-bearing deposits.*

" As far as I am able to judge from my examinations, it is only the alluvial deposits which contain gold in any quantity to speak of. From the two kinds distinguished above, the red clay is very poor ; the result of several hours' washing, with about 16 men, was a small show of gold. I must mention that I washed at a place which had been pointed out to me as very rich in gold.

" Better results are obtained from washing the river-deposits for gold ; and as these are especially developed in the Sonapet and adjoining valleys, it is to this locality to which particular attention must be drawn, It is. however, very difficult for the present to judge as to the quantity of the gold-bearing sands therein deposited, because the actual surface of the rocks is very irregular ; the deposits may therefore be thick at one place while a few yards distant from it they are reduced to a few inches in thickness. But assuming the area over which the gold-bearing alluvial sands are deposited to be 15·3 square miles, and supposing further that the average thickness is not more than 3 feet, the total quantity would amount to 1,280 millions of cubic feet ; now, supposing that 40 cubic feet of sand are one ton weight, the total quantity would amount to 32 million tons ; supposing that ½ million tons would be washed every day, the probable existing quantity could only be exhausted in 64 years. In New South Wales, the lowest return of gold in one ton has been 4·34 grains ; now, supposing that the Sonapet sand contains the same percentage, the annual yield would amount to about 4,500 ounces ; even if the quantity is reduced to 2,500 ounces, the yearly profit would be a considerable one,

" The Sonapet gold-bearing strata are therefore what is known in the language of the gold-mines as " shallow placers " or shallow diggings ;

and the stage of exploiting them should therefore be adapted according to this way of occurrence. The hydraulic way would certainly be the best, but I suppose that it will be very expensive.

"*(c) The origin of the gold in the Sonapet valley.*—It is a very general belief that gold which is found in alluvial deposits of a stream or river must come from some rich veins, which ought to be found in that part of the country where the stream or river takes its origin. It is true, of course, that the gold must come from somewhere in the upper parts of such a river ; but it does not necessarily follow that it comes from rich veins. The gold which is washed out of the sands in the lower part of the river was very likely originally disseminated through thousands of tons of rocks, which have been slowly but constantly disintegrated during past ages. The final result of such a long lasting process is a relatively small quantity of refuse in which all the heavy minerals, or those which do not disintegrate easily, have been concentrated, amongst them the gold first of all. Therefore strata which were originally poor in gold can produce deposits comparatively rich in gold, but if these have been exhausted, it is of no use to exploit the original matrix.

"To confirm the above, I quote here such an authority as Lock. In his work 'Practical Gold-mining,' page 136, he says : 'In these shallow diggings nature has for ages been performing the work for which the quartz miner must invent all manner of machinery, and employ a vast amount of capital and skilled labour—the disintegration of the gold-bearing rock and the concentration of the metal, which under its original condition disseminated through quartz and other hard rocks, often in invisible proportions, would have needed vast amounts of capital and much machinery for its elimination, and would in many cases not have repaid the outlay.' I think it is useful to begin this paragraph with such theoretical explanations, because I am quite sure that a similar way of reasoning will apply in the case of the origin of the Sonapet river gold. I often heard the theory expressed that because there are comparatively rich alluvial deposits in the Sonapet valley, there must be rich quartz reefs and veins somewhere in the surrounding hills. This does not follow by any means, as the reasoning at the beginning of this paragraph has shown ; it is more likely that the gold is disseminated in very small proportions through the metamorphic rocks, and that it has been concen-

trated in the Sonapet valley which forms a kind of natural basin. It has been concentrated here in the same way as the gold-washer concentrates it artificially in his washing trough; the bulk of the refuse having been washed off.

"Such is my theory about the original matrix of the Sonapet gold; there may be quartz reefs, I will not deny that; but if they do exist, they have still to be discovered. At any rate I have not seen them. I examined a locality which had been pointed out to me as the outcrop of a rich rock, very carefully. Nor did I notice the characteristic and unmistakeable 'blue quartz' of the Mysore gold mines. I carefully looked amongst the pebbles in the river-beds for this variety of quartz, but I have never found it; and feel inclined to doubt its existence, although I will not deny it, as the geological conditions are very similar to those of the Mysore mines."

The feature to be noticed in this paper of Dr. Noetling is, that he differs very materially from the views of Ball, as laid down in the latter's map, regarding some of the rocks in this Sonapet tract, in so far as he states that the valley portion of the ground consists of the gneissic series. Of course, it is to be conceded that he professes to have examined the ground in somewhat more detail than was possible with Dr. Ball: but when his argument is sifted, it turns out that he considers this area as of gneissic rocks, because it is covered by lateritic *débris* or alluvial deposit like that he saw on the gneissic tract. Such an argument is valueless, and we prefer to follow Ball's indications.

Dr. Noetling did not see any gold in the reefs or quartz veins, nor did he recognize any indications in them which might have led him to infer that gold might eventually be found in them. So far he is warranted in his conclusions, at the time; that, unless further discoveries prove the actual existence of gold-bearing quartz, the existence of such reefs must remain doubtful.

Indeed, that is pretty much the conclusion one must come to regarding the whole of the great area of transition rocks, although the attempt now being made at a development of the country would seem to show that there are auriferous reefs in some parts of the country.

The quoted extract from Lock's "Practical Gold Mining" is not quite apposite. Lock is merely describing how one of Nature's processes has been the collecting or concentration of ores from degradation of the matrix originally carrying them, let that matrix have been veins or country rocks; but not to show that the gold so concentrated has merely been derived from country rock.

All the previous writers and observers had to fall back, as Dr. Noetling has done, on the obvious and persistent alluvial auriferous production of the country; because they did not see, or to some extent missed seeing, any likely reefs. He, however, introduces a fresh point in the alluvial discussion, and that is an institution of a comparison between the red clay including laterites and the river sands and gravels.

He is not quite clear as to whether these sands and gravels are the surface deposits (the latest deposits of the rivers), or those deeper and older forms which were got at by mining, as in the Ib Valley, etc.

But if we are not mistaken, part of his red clay, including laterite, must belong to the later formed superficial deposits; and as such it would be derived from the weathering of the country rock (hornblendics and trappoids, or chloritic schists of the hills encircling Sonapet Valley) which would account in

part for the small proportion of gold derived from the country rock.

Still, as we have stated in our remarks on Mr. Bosworth Smith's report, the amount of gold washed in this valley, traditional or otherwise, is not accounted for by the number or size of its reef indications; and therefore the balance of evidence is as yet in favour of derivation from country rock or other metal carriers rather than from reefs of quartz in this particular region.

SUMMARY.

THE whole of the evidence has now been laid before the reader; doubtless with some amount of repetition, without which, however, justice could hardly have been done to the observations of the later writers; but it is hoped with sufficient detail to show how really poor that evidence is in the way of geological data bearing on rock gold mining.

Certain legitimate conclusions can, however, be drawn from the evidence such as it is, which may be summarized as follows:—

1. The southern half of the Chota Nagpore Province is certainly an alluvial gold tract.

2. The northern portion is only very locally so.

3. The proper alluvial auriferous tract is confined to the great area of transition rocks (distinguished by purple colour in the map); the westerly extension of which is, however, only provisionally limited in that direction by the boundaries on the map. Auriferous alluvial deposits may also be presumed to

exist in other but smaller outlying tracts of transitions not laid-down in our map, but which are mentioned by Ball as reported in the direction of Hazaribagh and the Lohardaga District.

4. The more special restriction of auriferous washing to the transition tracts shows that the gold must have been derived from matrices in the transition tract: whether from the country-rock itself or from veins or reefs in it.

5. There are certain conditions reported of the gold obtained from washings, which seem to be inconsistent with the theory of derivation from country-rocks alone.

Small masses of gold, usually described as nuggets, have been obtained from time to time, although it is very questionable whether they ought to have been called nuggets which are usually understood to be more or less waterworn and rounded masses of gold. A piece of gold in the Geological Survey Museum, weighing 199·6 grains, is an exceedingly jagged and cavernous specimen, which could never have travelled far, and which must have come from a reef or fissure rather than from country-rock. Occurrences of free gold of such a size as this in country-rock are unknown in India. Similarly, a good deal of the washed gold, recorded by Col. Dalton and others, was ragged and even wiry; just such gold, in fact, as would come from reefs, or other infiltration media, rather than from the country-rock.

6. The gold from the river sand washings and from surface washing, meaning thereby gold obtained otherwise than from pits in the older gravels, has in very many localities been derived from the wear and tear or denudation of the older alluvial tracts.

These washings occur also along the banks of rivers and at certain upland places in the crystalline area ; and undoubtedly their gold must also have come from older alluvium, or from outlying transition tracts, or, exceptionally, from reefs in the crystallines.

7. Quartz reefs and other infiltration matrices are known to occur in the transition area, though not known as yet to be in any strong development : and the inference is that the ragged and cavernous gold must have been derived from some of these reefs.

8. There is a tradition of one reef, which is said to have been mined for gold ; and it is said to have been lately recognized and found to contain gold.

9. The most damnatory evidence against the occurrence of auriferous reefs is, however, this single traditional case. All over the country, actual rock mines have been excavated for copper ores by a race of people concerning whom there is now no recollection ; it may be presumed that had these people known of gold in reefs they would have worked them too.

10. We can only account for this paucity of evidence of rock mining for gold on the view that copper indications in the rock itself as it were stared the people in the face. The conclusion from this is that reef gold was not evident ; and that therefore either the auriferous portions of such reefs as once existed have been entirely denuded, or that auriferous reefs are exceptional among the quartz infiltrations which do occur.

11. This probable rare or partial occurrence of auriferous reefs is all that the evidence before us will really allow : and

this conclusion must be kept well in view, notwithstanding all the dreams of possibilities which may arise out of so much that is really unknown of the metalliferous conditions of the province. There is undoubtedly room in such a huge tract of distribution of alluvial washings for somewhat favourable conjecture that reefs may be more numerous; but they have to be found and then tested, a decided move in which form of exploration is at last being, made after all the desultory and haphazard scratching at the surface which has been so prevalent during the last 12 months.

PART II.—COPPER AND LEAD.

THE knowledge of the occurrence of the baser ores in Chota Nagpore is tolerably contemporaneous with that of gold: indeed, many of the writers from whose papers or reports our extracts have been taken wrote on both subjects, although we have thought it more convenient for the reader to place their material under separate sections.

With regard, however, to the copper and lead ores; the evidences of their existence in their proper rock matrices, as well as of numerous ancient mines, are so abundant that there is really no necessity in this chapter to again interrupt the sequence of narration by the interpolation of hints at, or descriptions of, the rocks, or vein-stones, in which the ores are likely to occur. The authors themselves are, as a rule, sufficiently detailed in this part of their accounts for the *bonâ fide* mineral exploiter to follow up the trail so left by previous observers. It is, indeed, exploitation or actual preliminary mining, as distinguished from mere exploration or the more usual indiscriminate knocking off of samples of ore stone or *gossen*, which is required for the development of such copper and lead as there is in Chota Nagpore: and the selections of favorable sites for such operations should be a matter of little difficulty, where the results of explorations are so well set forth in the existing literature.

1833. Jones. Copper in Dhalbhum.

The first published notice of the presence of copper ores in Chota Nagpore was by Mr. Jones in 1833, who stated that

he had reason to suppose that copper might be found in Dhalbhum, near Rajwaha, in a stream called Guru Nadi, which empties itself into the Subanrekha.

1842. Piddington. Assays of Lead Ores, &c.

The earliest reference to lead ores occurs in the Proceedings of the Asiatic Society of Bengal for 1842, whence the following extract from a report by Mr. Piddington, Curator of the Museum of Economic Geology, has been taken :—

"*Museum Economic Geology.*—I announced in my last report an ore received from Major Ouseley, Agent to the Governor-General, S. W. Frontier. As I supposed, it has proved to be an argentiferous ore of sulphurets of lead and antimony in varying proportions, with iron pyrites in a quartz matrix. I obtained from 500 grains of the ore, fairly taken as an average, one and a half grain of muriate of silver, equal to one grain of pure silver. This would give about 70 ozs. of pure silver to a ton of well picked ore, which in England would be worth working. I have written to Major Ouseley for more specimens (those sent being merely the outcrop of the vein), when we may perhaps find ores of a quality better worth attention ; the presence of the antimony being a favourable indication."

1843. Ouseley. Piddington. Lead Ore, Hisatu.

In the Proceedings of the Asiatic Society for the following year (1843), we find the following letter from Col. Ouseley to the Secretary to the Government of Bengal, dated 22nd May, 1843 :—

"Sir,—Herewith I beg to forward specimen of argentiferous galena from a place N. N. West of this, named Hisatu, for the inspection of the Hon'ble the Deputy Governor.

2. "From analysis here by Dr. Macrae, and the examination of it and tests applied by Mr. Piddington in Calcutta, reported in the Journal of the Asiatic Society, a very large proportion of silver is attainable. It

may be considered desirable by the Government to make further enquiry, and if, as anticipated by Mr. Piddington, the results should prove so very profitable, adopt measures for working the mine, which is within the Zemindary of Ramgarh. The lead ore is abundant."

This specimen of ore was sent by the Bengal Government to the Museum of Economic Geology for examination by Mr. Piddington, whose report upon it, made to the Secretary of the Asiatic Society, is as follows:—

"In reply to the reference to the Museum of Economic Geology by the Hon'ble the Deputy Governor in Council, accompanying a specimen of the ore and matrix forwarded by Major Ouseley from Hisatu, 12 miles N. N. W. of Chota Nagpore, under date of June, 1843, I have the honour to report as follows:

"My former report to which Major Ouseley's letter refers stated, not that 'a very large proportion of silver was attainable,' but simply that the proportion of silver then found '*would in Europe be thought worth working.*'

"The present specimen is a less favourable one, giving a mere trace of silver, and this is a just instance of the uncertainty of these small laboratory trials of ores, especially as far as relates to the value of minute parts. No two experiments agree, and when the proportion of the valuable ore is a mere fraction, the results are of course always the more uncertain.

"The appearance of the matrix, and the presence of the antimony are, as before remarked, favourable indications; *but they are nothing more*, and indeed my report might stop here, and be comprised in this, that the present specimen is an ore of little or no value in its present situation, and with present appearances, but offering indications worth further investigation.

"It may however be satisfactory to Government and to Major Ouseley to have the reasons upon which this view is founded, and I therefore take leave briefly to state them here, as it is specially within the province of our institution to explain matters of this nature.

"In all mining, and indeed in many other countries, it has been well remarked, that it is not veins and ores that are wanting, but *profitable* ores. It was the ignorance or neglect of this great and first principle in mining speculations, which sacrificed so many millions of English capital in Mexico and South America. The agents of the mining companies could not, or would not, suppose that a *silver mine*, or a mine which produced silver ores could be a losing concern, and they bought up, at enormous prices, hundreds of spots from which indeed silver was obtainable, but not to a profit.

"In the case before us, we have at the most, an ore of lead and antimony, with the minute portion or traces of silver which always accompany these ores, and supposing it to be obtainable in any quantity, and at the cheapest possible price, or indeed for nothing, we should still require all the expensive resources of the best European metallurgy, and establishments with scientific superintendence to render it a marketable article here. As a mere ore, it would probably not pay its carriage to Calcutta and freight to Europe.

"In a spot, then, affording only favourable indications, and where we have assumed already much that is doubtful, it is clear that the first step is to know—

I. What the vein really is?

II. What are the facilities for, and difficulties against working it, and the expense attendant on all these and on the necessary superintendence.

III. What those for transporting the product to a market are.

"The vein may be the outcrop of a rich mine, or it may be worthless or unworkable, or break off, even for lead and antimony, at 10 fathoms deep. It follows that a professional and a scientific man should first be sent to the spot with all necessary means, that a shaft or gallery should be dug, and the ores from it, as far as he can reach, be examined. This is necessarily and indispensably the first step.

"During the examination, all questions relative to the facilities and difficulties likely to attend on the working would be enquired into, and in India these are far more than Europe, as the following enumeration of a few of them will show: 1st, healthiness or unhealthiness of the site;

2nd, possibility of obtaining workmen; 3rd, of subsisting them; 4th, of erecting machinery, furnaces and the like; 5th, fuel; 6th, drawing or pumping water; 7th, general cost of bringing the ore to the *bank* (*i.e.*, to the mouth of the mine); 8th, cost of preparing, smelting, and produce of the metal at the furnace.

"Supposing the metal or ore to be thus obtained at a profitable rate, it has yet to be taken to a market, and this involves all the questions of road, carriages, warehousing, and agency in Calcutta, and perhaps even freight, insurance, duties, and sale charges in England.

1854. J. C. Haughton, Copper Mines, Singhbhum.

In Captain Haughton's Memorandum on the Geological Structure and Mineral Resources of the Singbhoom Division, already quoted in Part I, the following information is given regarding the existence of copper ores in that area : —

"There were vague rumours of the existence of ancient diggings for this metal when I first entered Singhbhoom, but on those spots where it had formerly been found it had long ceased to be sought for. There was no local tradition as to when, or by whom, the diggings had been worked, and it was a matter of doubt whether they were really made for copper. In Seraikela the zemindar assured me that the metal had not been sought for during the time his family had been settled there, that is for about a century.

"In 1847, I ascertained beyond a doubt that the metal existed. A small quantity of the ore was rudely smelted. This gave a little metallic copper. Since then the zemindars of Dhulbhoom and Seraikela have turned their attention to the matter, and some forty or fifty maunds of the metal are now extracted annually during the dry season.

"The localities of the veins known to me are Booreetopa in Khursowa, Narainpore and Jamjora in Seraikela, Landoo, and in fact the whole circuit of the Dhoba hill, Rangamuttee hill, a spot on the south side of the Kapergadee Ghat, Badea, Ooraon Ghur, and a spot near Kamerara, all in Dhulbhoom.

"The vein in Khursowa lies east and west. It is situated about three miles south of the town and a little north-west of the Moza Booree Topa. The vein has been laid open at intervals for about half a mile, but the diggings are nowhere more than about ten feet in depth. The matrix appears to be schists and quartz. The most promising specimens of the rocks picked up on the spot gave 25 per cent. of metal, but it was so largely contaminated with iron as to be attracted by the magnet. I think it probable that the vein is now quite as well worth working as it ever was; the operations have been entirely superficial, and it is manifest that a large portion of the vein remains absolutely untouched.

"Copper was formerly mined in a hill still called Tamba Doongree,* near Narainpore in Seraikela. The old shafts are very small and irregular. The largest was sixty feet deep. All appear to have been designed to be perpendicular. A very superficial inspection showed that the miners had worked completely at random. The hill consists of schists in contact with trap; the strike of the strata is No 86° east, and its dip about 45° north-east, but no regard appeared to have been paid to either. The only rock on which I saw any trace of copper was a trap, or possibly a very much altered schist. No attempt that I am aware of has been made to re-work this vein. The workings, as far as I could ascertain, were entirely vertical, so that the vein must have been quickly passed through, and, in such case, would be as good a speculation as ever. The old shafts are about twelve in number.

"The Jamjora digging I have not seen. It is said to be entirely new. It is manifestly a continuation of the Dhoba hill vein, or, more correctly speaking, part of the same system of veins. The ore is a very promising one. It is very friable, consisting, it would seem, of a decomposed schist. It contains but little sulphur, which enables the rude operators to smelt it directly; some specimens contain a good deal of bismuth and iron. Those examined by me gave an average of 22 per cent. of copper sufficiently pure to be marketable.

"I have been informed, however, that some specimens examined by Dr. O'Shaughnessy gave as much as 43 per cent. of metal.

* Copper hill.

"An English gentleman endeavoured in 1852 to obtain a lease of the mines both in Seraikela and Dhulbhoom. He was not successful. The zemindars, on whom I had strongly urged the advantage of employing European skill and capital, objected to me that the "*Sahib logue*," once admitted, soon become masters of their estates.

"The copper vein at Landoo, as I have already remarked, appears to belong to the same system as that at Jamjora. I have not examined the ore, which appears to be more compact than that just mentioned, and probably contains quite as much metal. The present working is, I believe, new ; but I traced round the foot of Dhoba hill with which it is connected the scoria of old furnaces for some miles, all memory of the workers has perished.

"About three miles east of Kalkapore in Dhulbhoom is a hill called by the Hindoos Rangamittee, and by the Coles, Sontals and others. Sengil Booroo—the Cole equivalent for "fire mountain." This hill, which consists of altered schists. rises about eight hundred feet above the surrounding country ; half way up are perpendicular cliffs of foliated schists which contain copper, and I have ascertained the presence of the metal in an ore of iron taken from the very top of the hill. No mine has been attempted here. Oxide of copper is scraped in small quantities from the surface of the rocks, where water finds its way from above, and is sold in trifling quantities by the natives The only use to which it is applied that I could hear of is for blackening the teeth of the ladies.

"At the base of the above cliffs is a fissure, the mouth of which is only just big enough to admit a man's head. It is regarded with superstitious dread by the inhabitants of the neighbouring villages. When at Kalkapore last year I, through the influence of the Sirdar Ghatwal, collected a party to visit it. It was evident from the stories told that a visit to it had been a rare event : nothing daunted, I climbed the very steep hill at dawn, and with some little difficulty reached the place.

"The cavity appeared to penetrate the hill horizontally. As we had no light I could not ascertain whether it expanded internally or not, for my head closed the entrance. The natives who were with me could not be induced even to approach it. They asserted that unearthly noises were occasionally heard proceeding from it, and that in some years *after very*

heavy rain fire issued from it. I could not detect the odour of any gas exhaling from it, and the cave itself had no appearance of igneous action about it. A bush was growing a few yards in front, which could not be the case, had a jet of burning gas issued from it within a period of two years. There was a white waxy exudation (which seemed to me to be nitrate of soda) in small quantities on the rocks.

"The dung of porcupine and hill-rats showed that the cave was an abode of these animals. The Sirdar promised to send me notice on the next occasion of fire breaking forth, but though we have had some very heavy rain this year as yet no notice has been given to me.

"The mountain undoubtedly contains copper disseminated through a very considerable thickness—at the least some hundred feet of rock. Whether it contains a vein of sufficient richness to repay the labour of working careful examination must decide.

"The copper vein at Badea may be traced for about two miles in a north-westerly direction into the jungles. Its course is shown by a series of pits verging in depth from ten to forty feet. It has not been worked within any traditional period, and trees of large size grow on the edges of the pits. I have not seen any genuine specimen of copper ore from this locality, though fragments of quartz coloured with the oxide of that metal are abundant. A specimen was handed to me from the immediate neighbourhood as containing lead, which it was asserted had been extracted the year before from the same ore. I failed however to find any trace of lead in it, but think that the results warrant me in saying it contains a little tin. My means were very imperfect, and the examination a very hasty one. I have no doubt that Mr. Piddington, who has it under analysis, will be able to decide the question. The traces of copper found at the Rangamittee hill I have little doubt are a continuation of the same vein or series which exists at Badea, for the metal is again found at Ooraonghur about four koss north-westerly, and again at an intermediate point near the Kapergadee ghat. I have not visited these places, nor have I any particular description of them. They suffice to show that the metal is found in one right line for about fourteen miles.

"The Badea workings would yield as much profit now as they did originally, the outcrop of the vein having been alone worked, and between

each pit as much space as occupied by one pit is left apparently untouched. Time did not admit of my clearing the soil sufficiently to ascertain the dip; the strata were, as well as I could judge, nearly vertical. The strike determined rudely by the direction of the pits is N. 27° 14′ easterly by compass.

"Close to the digging, on the road where the soil has been broken down by carts, small quantities of gold are found, amongst gravel consisting of quartz and schist.

"Iron is also found near at hand. The ore of the latter is of a sort unique in this quarter.

"Two and a half miles north-east of Kemerara are some more old copper diggings. These run in a northerly and southerly direction as those at Badea for a couple of hundred yards. They are entirely the same in character; some specimens of the ore which were handed to me by Mr. Campbell gave 24¾ per cent. of copper. The ore is hard and vitreous and contains much sulphur with some iron.

"The richest veins of copper within the Singhboom division are apparently those of Landoo and Jamjora; but it is possible the old diggings, if carefully examined, might be found to contain equally good ore. The open workings are liable to be filled with water from the rain, but I think the shafts sunk into the soil would be found to require less drainage than usual. The freedom of the ores in general from sulphur and their softness renders them well worthy of the attention of speculators. Labour is cheap and abundant, and if that on the spot fail Dhangurs may be had from Chota Nagpore at the rate of about Rs. 2 per mensem. The Bhoomij of Dhulbhoom, however, often goes to the Mauritius classed a Dhangur. Wood-fuel may be had in sufficient quantity to last eight or ten years near all the localities named. I am unable to say whether coal could be brought at the end of that time at a rate sufficiently low to admit of its use. The Raneegunge collieries are, I think, the only ones which could be thought of for the supply.

"From the diggings at Kamerara there is a good road only eighty-five miles in length to Tumlook. The distance from Landoo or Jamjora to the Cossye river at Dhee Kullianpore is about seventy miles, and that

river might, it seems probable, be available for water-carriage during short periods in the rains, as the Damoodur is at points far above those where it is ordinarily navigable. There is every facility for the construction of a good road to Dhee Kullianpore or to Midnapore, and in fact there was formerly a Government route in nearly the same direction; the old road from Gurbheta in Midnapore to Sumbulpore, which might possibly be still available for some distance, though it has been abandoned by Government these thirty years. The distance from Tumlook *viâ* Midnapore would be about 132 miles.

1854. H. Ricketts, Copper Mines, Chaibassa.

The following extract from the Report on the District of Singhbhum, by Mr. H. Ricketts, published in 1854, refers to the copper mines of Chota Nagpore:—

"In consequence of what I heard from the principal assistant, stationed at Chaibassa, and also from several parties in Calcutta, I penetrated to the copper mines.

"Those I visited are situated about eight miles north-west from Kalkapore in Dhulbhoom, and nine miles north-east from Hessel in Singhbhoom. There are traces of considerable diggings in many places, but of very old date The hills are cleared of jungle, and in the woods below the heaps of refuse may still be traced. Though the hills in which the ore is found are far in the woods, there are no real difficulties of any kind; already supplies of the common articles of food may be procured at a short distance, there is a small supply of water near the mines, and it might easily be increased to any amount by throwing dams across some of the vallies close at hand. A good road to Kalkapore and to Chunderleeka on the Sabenreeka river may be made at but little expense besides cutting the jungle. The Rajah of Dhulbhoom is quite ready to give speculators a pottah for the lands on reasonable terms. He would give the hills within a circle to be marked out at a very light rent on perpetuity, he receiving a percentage on the produce. He would readily on these terms afford the farmer his assistance in procuring people. But no assistance of that sort would be required, good wages would soon bring the hardy labourers of Chota Nagpore.

"I have forwarded specimens from the old mines, and also from the new vein, discovered not long ago, when the digging has been carried only six or eight feet from the surface. I am not qualified to give an opinion respecting the value of the ore; Captain Haughton says, "from examination of the ore made by myself, it appears that 24 per cent. of pretty good metal might be safely reckoned on from the Jamjora ore, which much resembles that of Landoo. Its chief excellence however lies in the softness of the ore, which allows of its being easily worked, and in its freedom from sulphur; this last quality greatly simplifies the process for the extraction of the metal. All the veins, which appear to be very extensive, require examination, and the ore, careful analysis by a competent person."

1857. C. Durrschmidt, Copper, Singhbhum.

In 1854, Mr. Durrschmidt visited Chota Nagpore in the interests of a company; and three years later, his *Report on the Copper Mines of Singbhoom, in the South-West Frontier of Bengal*, was published. After quoting the report of Mr. H. Ricketts (already given in part) and that of Captain J. C. Haughton, he writes:—

"During the past cold season I examined the whole extent of country and critically surveyed most of it, aided by the chiefs of our scientific staff, *viz.*, Professor Emil Stoehr, of the Bavarian Service, and late Director of the Copper Mines on the Murtschen Alp, in Switzerland, and Rudolphe Schenck, of the University of Carlsruhe, miner and smelter.

* * * * * *

"On entering upon our enterprize, we were inclined to regard the native workings as insignificant, but the more we examined them, the higher opinion we had of their importance, and it is really wonderful to view what has been accomplished. The memory of the men who must have directed these works has entirely died out, and the Rajahs, whose families have been in possession of the country for centuries, can give no reliable account in regard to them; the only trace of history we were enabled to obtain was from a legend believed in Rooamghur.

"Rooamghur, they say, was a hill fort, and the residence of Rooam Rajah, who got up these mines and forced the people to work in them. The legend speaks of the Rajah as having "two tongues," signifying no doubt that he was a foreigner, but from whence or of what country it was impossible to discover. After the death of this man it is said that his people were expelled and the mines deserted. The site of this place is in a commanding position, on a spur of the Sherdishur mountain, and the remains of the old ditch round the fortress is still visible. The place within where a town is said to have been is now covered with copper and iron slag without trace of buildings, but on the Mahadeo hill which is connected, no doubt artificially, with Rooamghur by a high dyke, we found the ruins of the wall of a fort and an old watch tower. Explorations here would be highly interesting as likely to throw more historical light on the locality.

"There are no blastings in any of the old mines, and the time occupied in making such extensive excavations as exist with the aid of mere chisel and hammer must have occupied at least 100 years. Without the aid of gunpowder mining became to them unprofitable when hard rock was met with, but these early adventurers have shewn great cleverness in working out the nests of soft ore. Their working passages are rarely larger than to admit of a single man, and they seem to have known nothing of the art of timbering, but have left standing pillars of ore. Working in this way the mines necessarily became intricate, and the water must have greatly inconvenienced them, rendering impossible all deep diggings: hence the enormous number of mines opened, all of comparatively little depth. Every possible spot where the vein appeared, or was indicated, seems to have been opened. Those worked longest show the largest heaps of slag and rubbish; others seem to have been early abandoned. By these old workings we at once trace the vein with certainty; the advantage derived from this knowledge is of the highest importance and usefulness. There is no doubt that one or several veins of copper ore run through the whole district, but have been worked only where risings had brought them to light. The lode seems to be extremely constant, but richer in some places than in others, and as it invariably runs parallel to the slate in which it is imbedded, I am inclined to look upon it as a stratum and not a vein.

"The ore seems to be a fahlerz or grey sulphuret of copper and iron, but in the upper part of the vein it is changed into malachite. It is an ore very easy to smelt, and the natives have proved this, as the heaps of slag attest, containing as they do but very little metal, and the cakes of made copper found are of excellent quality and purity. This cupriferous stratum, or vein of copper, appears first in the west at the foot of the hills of Chota Nagpore, near the Nepesu hill, and is traceable in a series of old workings down to Bairagoora, an extent of nearly 100 miles.

"The most western mines that I have seen are about five miles east of the Nepesu, near the village of Barasai, whence they stretch for about one and a half miles to the village of Kadumdia. These mines are nearly in a plain, and going first through a thick stratum of alluvial soil have all fallen in, and it is only the quantity of rubbish taken out which can give a key to their importance. These show the same character as those found in Landoo with a little more mica; the ore found is also of the same description.

"Following the direction of the strike, which here is nearly due east and west, the vein is found to be broken through by a system of small trap hills, and further east is covered with deep alluvium in the valley of the Sunjye river. It only re-appears near Narainpore, where a hill called Tamba Tungri (copper hill) has raised the strata to a considerable height. I have carefully examined these works which are very large. A great number of shafts have been sunk here, some open even now, to the depth of more than one hundred feet, and these people having sunk many of the shafts of such a depth, as near as one hundred feet from each other, shows that the vein must be very rich indeed.

"The character of the rock and ores is the same, and heaps of copper slag all round attest a large production of copper. About two miles further east the vein shows again near the village of Rangamutti, but the works are small. It next appears near Chota Jamjori, where an accidental digging discovered it in the middle of a rice field. This discovery shows that the vein goes through under the alluvium. These ores are very fine, the whole stratum containing from 10 to 30 per cent of copper.

"The Rajah of Seraikela tried to work these ores some years ago, but the mine soon stopped itself by the quantity of water which accumulated in their tank-like working. We are now working here, and the vein shows about twenty one inches thick, with very fine ores, at present mostly malachite, but no doubt further down they will prove a compact sulphuret of copper. The mine is very promising, and the workings are being prosecuted vigorously. From this the vein is shown by a series of old shafts to Landoo, where it all at once becomes a triple one. This spot was chosen to examine into the vein by mining operations, and a number of shafts were sunk in different localities, of which four are now working.

"No. 1 is an old mine where the the natives had stopped working when the stratum showed no copper. We pushed forward a shaft on the stratum on an incline of about twenty-five degrees, and soon came to the ore. The stratum at first had scarcely 2 per cent of copper, but at the depth of sixty feet this increased to 8 per cent, and a gallery driven to the east, now a hundred and forty feet long, shows this to be constant, the lode varying in thickness from fifteen to twenty-four inches. The shaft met a dislocation of the strata at about 150 feet deep, but was continued, and the ore again exhibited itself, but our workings extended to nearly 200 feet before it again became compact and regular A gallery is driven to the west at 105 feet deep to examine the range of the fault. The original ore is a sulphurated one, most probably a mixture of fahlerz and the red oxide of copper with iron, and the analysis of the pure ore, not changed by atmospheric influence, is as follows:

Copper	...	... 51,040 or	50·8
Sulphur	...	... 6,120 ,,	7·4
Iron ...	...	.. 18 660 ,,	18·3
Bismuth	...	... 0·462 ,,	trace.
Silica ...	...	... 2 886 ,,	1·6
Loss, water and carbonic acid		... 20·832 ,,	21 9

"But even at the depth of 200 feet the ore is still partly changed into malachite, and it is quite clear that a great deal of the ore has been washed out in the upper part, as the rock is coloured green far from the ore.

"Shaft No. 4 is sinking on the same vein about two miles west, and is now about 70 feet, deep, but will not reach the vein under 100 feet or more.

"No. 2 is sinking on the second vein about a mile south of No. 1, where there are considerable old workings, but has not yet reached the ore.

"No. 6 is on the third vein half a mile more south and an old mine re-opened. Here the rock is very firm, the ores are less decomposed, and therefore richer, but of the same quality. We are now about 90 feet deep and have very fine ores. Many more shafts were sunk to examine the formation, but only those named have been continued. None of the mines have been worked for ore as yet, our object being to open out, test and examine, but Nos. 1 and 6 can now be immediately worked, and the former would easily produce 1,000 cwt. of ore a month at little cost. We could now put on this shaft 18 or 20 men to cut ore. A European miner would cut in a month in similiar rock three fathoms, taking out as much of the rock as to give him room for working, besides the ore. I reckon a native miner at only one-third of this, which is reckoning very little; eight men working day and night, or 16 men a day would thus give in a month 1,200 cwt. and cost as follows:—

	Rs.	A.	P.
16 men at 7 pice a day	52	8	0
4 Sirdars at Rs. 4 per month ...	16	0	0
Tools, Oil, &c.	30	0	0
Rs.	98	8	0

"Say Rs. 100 for 1,000 cwt. of ore, besides the direction and general establishment, which of course will fall heavy on a small production but will be scarcely felt on a large one. In Landoo, which is our sudder station, we have houses, workshops &c.. and here Dr. Stœhr, the director, resides with four European miners. East of Landoo the northern vein is seen to continue, or rather the several veins converge into the Chundroo hill about 500 feet high which has raised the stratum.

"The natives have taken advantage of this favourable position, and have made immense mines at the top of the hill where the ore was exposed. We are now working here, and shall fetch the vein by a gallery at the foot of the hill which will at once open out a large quantity of ore. Going further east we come to Matkoo and Hitkoo lying in the plain At both places small traces of old mines had been found and we sunk to examine them, finding in both places large mines through which we are sinking now. The ores here are compact sulphurets, with here and there crystals of copper pyrites and contain about 32 per cent. of copper.

"Some native copper has also been found here. These mines are very promising, but the quantity of water accumulated in the old workings requires many precautions, and therefore the progress is slow at present. We have a bungalow at Hitkoo; here Mr. Schenck resides with a European miner. There are several other old mines in the neighbourhood, and one on the Banka hill shows curious features This seems to be a piece of the vein carried up by a trap irruption, and the quartz which forms the matrix is perfectly burned and full of veins of sulphurated ores, as well as of the black oxide of copper.

"After this we come to the Nerua and Rangamutti hills. Here the Goorooroo river has broken through a gorge and the ends of the strata are exposed. The works at the Rangamutti are very considerable. This hill is a spur of the Ranga hill, the highest of the range of hills beginning here, and probably above 1,200 feet high. It is composed of metamorphosed slate and quartz, and in many places shows traces of copper. East of this the vein most probably is covered with alluvium, but reappears on the Raka hill, where there are mines in several places. A couple of miles further east on the Bagkara hill, the vein has been extensively worked, the old diggings extend over more than a mile until the hill dips into the small valley of the Tanjeekussum brook. As soon as the ground rises again, the vein reappears and has been largely worked on the Gawai Sal hill.

"Hence it is lifted up to the Sookoona hill and forms its northern slope in which many shafts have been sunk. A deep gorge divides this hill from the Bindabun hill, and the vein is exposed on both sides. The

old workings here are very large, perhaps the largest we saw, and the heaps of slag all round attest a great production of copper. The mines continue along the Bindabun hill to Rooamghur, the legend attaching to which I related in the early part of this report, and it is a likely conclusion that mining operations spread from this place. The gorge between the Sookoona and Bindabun must have exposed a great length of the vein and been very easy to work at first. Southward the Bindabun is connected with the Sherdishur hill, a conical mountain of about 1,200 feet high, composed of quartz rocks, which in many places show nests of copper ore, and some shafts have been sunk here. The vein is again shown by old workings on the Neturghat hill, and if it continues in the same strike it would fall in the plain.

"A few miles south it appears in the Pattertungri, or stone hill, where the workings are very large, and follow the hill more than a mile and a half, until it is lost in the valley. North of the Pattertungri there are mines near the village of Surda in the plain, and towards Patterghurra village the vein seems to be again a triple one, and has been largely worked in many places. It now falls into the plain, and from Baragoria the old workings continue almost without interruption to Badea, where they are lost under the alluvium of the valley of the Sunck river. The vein must lie flat here, as the workings are open trenches, and shafts have been sunk far north of these to reach the vein deeper. This will most probably prove an important locality for working. East of Badea the vein reappears in the hills, but these being trap irruptions have cut it off, and we could not trace it in the next 8 or 10 miles, though I am convinced it is somewhere adjacent as we found copper slag; most probably it is further in the hills which stretch to the Sutbukra mountain.

"About 25 miles further south-east in the direction the strike points to the vein has been again worked at Rutnakoon and Morado near Bairagoora. The diggings have been open workings, but the formation of the rock is not quite the same as further west, yet the mines must belong to the same vein, and from all these facts I have no doubt that it runs through the country.

"Besides copper ore there is iron ore of many kinds and excellent quality all over the district, and the natives smelt it everywhere in their

small ovens This metal is at present of no importance, as the transport would cost too much, but most probably it may become so hereafter, and at all events I propose to produce all the iron for implements wanted in our mines. This iron is well adapted to the manufacture of steel, being mostly from pure magnetic iron ore, smelted with charcoal. In addition to iron I may mention gold.

"I have given the subject of this metal considerable attention, but do not think it desirable or profitable to work it. It occurs in most brooks and rivers, and is washed to some extent. There are also some localities where the people fetch gravel, and wash it for this metal, but the women who work at it make a very scanty living and seldom earn two annas a day. The gold occurs in minute particles, and no doubt is distributed in the alluvium. The source must have been westwards, as the pellicles are larger there. There are traces of bismuth in some of the ores, but no other metals have been found, nor are we likely to find any.

"The copper ores will be smelted on the spot, and we have on the vast hills stretching along the Soobunreeka to Bairagoora an almost inexhaustible supply of wood for charcoal. The forests for the most part consist of sal trees with little low jungle.

"Smelting experiments are now being made, and in the coming cold season regular smelting operations will be commenced upon.

"The whole establishment on the mines is under the direction of Dr. Stoehr, late Director of Copper Mines in Switzerland. Mr. Rudolphe Schenk, practical and scientific smelter of Freiberg, will specially attend to that department, and five European practical miners selected from the mines of Saxony to act as foremen and to instruct the natives in the art. Native labour is abundant and cheap, and the men willing workmen.

"The access to the country from Calcutta is by no means easy, but Government have lately made a fair-weather road from Midnapore to Chyebassa, and this is good enough for carts to travel on, except in the height of the rains, but no doubt Government will improve this road on our trade assuming a higher importance. The distance from Midnapore to Nursinghur is 59 miles, and thence to Landoo 27 miles, and carts take eight or ten days to go loaded from Midnapore to Landoo.

"One great advantage of smelting in the country would be a saving of import charges and duty, thus lessening the cost to the consumer, and with a lower standard of prices consumption would be largely increased. From all the facts I have detailed it will be self-evident that this property is an immense one, and from the extent and constancy of the workable vein can produce more copper than all India can consume and at a price defying competition."

Then follows a description of the *Copper Formation in Dulbhoom and Singhbhoom, S. W. Frontier*, by Emil Stoehr, Esq., Geological and Mining Engineer, late in the Bavarian Government Service :—

"Attention of late years was first directed to this formation by Capt. Haughton's visit and report published in the Journal of the Asiatic Society of 1854.

"For the last year and a half I have been charged with the development of this formation, and now beg to report the following results of my examination. The copper ores are apparently spread over a continuous distance of upwards of eighty miles of country on the right side of the Soobunreeka river which here flows in a deeply cut bed from N. W. to S. E. through the territory of the Rajahs of Dulbhoom and Seraikela and the small possessions of the Thakoor of Kursowa. The present proprietors have obtained the mineral rights of these territories from the Rajahs, and have been in possession of them for some time, so that their rights extend nearly over the whole formation. Ascending the river Soobunreeka from Bairagoora, we see hills rise on its western shore and continue in its immediate vicinity up to Badea, where they recede for the first time and leave a wide valley. But soon they rise near the river again and continue to the Rangipahar, where the hitherto compact chain suddenly ends. Here we come into a plain stretching far west, only interrupted by isolated ranges of hills and conical elevations rising like islands upon its surface. The hills east of the Soobunreeka have their point of culmination in the Dulma, 3,050 feet high, and are lost in the plateau and hills of Porahat, Sonapet, and Chota Nagpore.

"Our surveys do not comprise the whole district, but the most important portion between Badea and Jamjori, and nearly two-thirds of the whole, are accurately drawn in from minute survey.

"The mass of the hills do not rise more than a couple of hundred feet above the plain, a few mountains only making the exception, *viz.*, the Rangi 435; Toolia 326; Sherdishur 316; and Dhoba 331 metres above the plain at Nichooa. The western hills seem lower than they are, as the plain rises gradually and steadily and reaches a considerable height in the west. Often thus the range of hills nearly disappears and undulation of a few feet only show that they continue. The strike of the hills is W.N.W. by E. S. E. (in the West Hora 6 to 7 in the Eastern part h. 9 to 10*) and they form a system of parallel chains which often meeting each other form funnel-shaped valleys.

"Interrupted by plains, the map shews three groups of hills, the middle one being the highest and describing a triangle with the Sherdishur mountain in its apex (though the Rangi is the highest peak and not the Sherdishur). After this the group S. E. of the valley of Badea and last the isolated group of the Dhoba. West of the Sherdishur the strike of the chain is h. 7 to 8; after this it becomes more southerly, *viz.*, h. 9 to 10. All these groups are separated from each other by plains, the largest being west of the Dhoba chain, in which only isolated cones rise stretching west of the Nepesu and Kursowa to the plateau and chain of mountains of Chota Nagpore.

"This range of hills stretching, so to say, east and west is ever indicated in the plain by slight undulations, but disturbed, as some of the ranges recede or advance in step-like order. In other places the chain becomes bifurcated, when often one range is quite lost in the plain or both join again.

"Besides these disturbances natural to all mountains, we find that these elder elevations have in many places been intersected and disturbed by risings of a more recent date which form hills in the direction from south to north.

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* The German mining compass is divided into twice 12 hours (Hora), 12 is the line North and South, 6 is the line East and West, and so on.

"The S. N. risings form no chains of hills, but their direction is indicated only by isolated and very picturesque conical hills. Where such S. N. risings intersect E. W. chains, the latter rise to a more considerable height, and in their vicinity the rocks are scattered and contorted. The geology of this country is intimately connected with its configuration.

"The strike of the rocks coincides generally with the E. and W. hills, and therefore is in the western part h. 6 to 8, and east of the Sherdishur h. 9 to 10, the surest proof that the erection of the strata is coeval with the upheaving of the chains of hills.

"The dip is constantly north, varying from 15 to 20°, and sometimes 50 and more degrees, and as all the hills slope gradually to the north and show steep precipices to the south, the upheaving cause must be sought for southward ; only where N. and S. elevations interfere the strata are confused.

"The rocks of the mountains belong to the oldest stratified non-fossilliferous formations mostly metamorphosed and consist of a great variety of mica, chlorite and particularly clay slates changing one into the other, which, getting impregnated with silicious matter, have become complete quartzites which compose whole mountain chains. Far stretching dykes of white quartz are frequent, sometimes they are coloured by carbonaceous matter, and have become real Lydian slates (Jeweller's Touchstones). In other places the slates grow gradually more micaceous and change at last into mica slates, enclosing crystals of garnets and tourmaline as well as hornblende. Occasionally there appear loose masses in layers of real potstones which are extensively worked into all sorts of dishes.

"The strata are frequently metamorphosed most where S. and N. risings have intersected them. In such places metamorphosed clay slates and basaltic jaspers are found and the quartz appears calcined.

"In many places the rock gradually becomes real gneiss, which again changes into granite and towards the south we see granitic domes.

"The south and north elevations which have broken through these rocks differ entirely from them. They consist of greenstones and diorites, the latter showing a tendency to concentric disintegration

These conical hills mostly exhibit the appearance of colossal heaps o blocks of rock of the most picturesque form.

"It is my opinion that these S. and N. elevations are contemporaneous with the trap of the coal formation. These districts, of which I have detailed the general outline, contain gold, iron and copper.

"The first is of little importance and is washed only in some few rivers.

"The iron ores (often magnetic) belong to the best in the world, and are smelted by the natives in small ovens directly into malleable iron.

"If the means of transit were better these valuable iron ores could be worked with great advantage.

"Nearly all the strata contain more or less iron and sometimes, particularly in the vicinity of the S. and N. elevation, they become real iron ores.

"The copper ores occur in a long stretch from the Nepesu in the west, down to Badea and even to Bairagoora, more than eighty miles in length.

"They appear either in the northern spurs of the higher ranges of hills, or in the plain where small risings bring them to light.

"The strike and dip of the lodes everywhere coincides with the strata, and these again are conformable with the configuration of the surface.

"Therefore the lodes spring forward or backward in a step-like form or bifurcate like the hills in which they lay. In several places we see two or three such lodes, one behind the other, probably belonging to the same system brought to light in several places by the risings and not to several parallel lodes.

"Copper is not the only metal which the lode contains. Iron is found everywhere and mostly is predominant.

"The quantity of copper varies from mere traces to the total exclusion of iron.

"The lode is by no means equally rich in all places; there occur long intervals where it contains no metal, and rich fields only occur at intervals, sometimes forming nests of considerable extent.

"The ores are sulphurated ores where they have not felt the atmospheric influence, the proportion of iron and copper varies, but in none is the amount of sulphur large.

"Analysis of pure ore gave 50 per cent. copper; 18 per cent. iron; 7 per cent. sulphur.

"These ores appear as threads and ribbons in the matrix of quartz, often as spheroid masses of a few inches up to several feet.

"Wherever the ores have been exposed to atmospheric influence, which is very intense in India, they are decomposed on the upper part of the strata and have become malachites, and sometimes the blue carbonates, but in most cases the whole stratum has become impregnated by copper. Besides this we find there the black oxide of copper incrustations, produced most probably by the influence of the S. and N. elevations and also native copper in threads and rosettes.

"The undecomposed ores often contain specks of copper pyrites.

"Nearly in every spot where a rising had brought the vein to the surface, the ancients have carried on clever mining operations and worked for ore, and large heaps of rubbish designate the richness of their workings.

"The ores must have been smelted on the spot in small furnaces, as heaps of slag invariably gird the old workings.

"Before I detail these localities, I beg to observe that the matrix of the lodes is mostly quartzose, but claystones, chlorite slates, and even mica slates are of frequent occurrence, and here and there we even have talcose concretions.

"The old mines have mostly fallen in and no rocks can be found, as they are covered by deep alluvial ground.

"The heaps of rubbish are not covered by vegetation, and where standing rocks are met they generally are covered with a thin crust of malachite by atmospheric influence.

"I begin in the west with the enumeration of the localities of mines known to me progressing eastwards.

"The first mine to notice is about six miles south of Kursowa between the conical hills Seratungri and Nepesatungri (Tungri means a hill).

In the plain there are two, and in one place three, parallel lines of very considerable heaps of rubbish separated by undulations of the ground. They stretch in large heaps above two miles west; everything is grottoed and broken in and covered with detritus, so that no standing rock is visible. The detritus is so considerable that a shaft sunk at the bottom of one of the funnel-shaped old mines reached no rock at a depth of 20 feet. The stones which compose this rubbish are quartzose slates and quartz; the only ores found were thin leaves of malachite. The direction of these heaps, which no doubt designate open workings of old, is about h. 6½, once I found it about h. 4½. A few miles off Kursowa we find some old mines east of the village of Bedumpore in the plain. They are on an E. W. rising, only indicated by an undulation of a few feet and are of some extent Further east they are cut off by a S. N. dyke. The predominating rock here is a micaceous slate.

"Some fine specimens of malachite were found amongst the rubbish.

"We then come to Kadumdiha, a little more east of Kursowa, and about two miles from here north of the conical hill Ackarsanni there are some more old diggings.

"The rising of the Ackarsanni seems to have disturbed the vein and the mines are small The rock is a quartzose black mica slate, and contains leaves of malachite—strike h. 6½.

"The next mines are about seven miles distant on the Tambatungri, in Seraikela. This hill, a S. and N. rising, has raised the vein, and the whole hill is perforated by shafts down to 100 feet deep. The rock consists of slates, rich in quartz, and pure quartz often metamorphosed by contact with diorite.

"In the slates as well as the dioritic rocks we find leaves and pieces of malachite. The strata seem to be considerably disturbed, but the strike is h. 6½.

"After an interval of about eight miles we find another locality where the ores exist in the plain near Jamjori on a western spur of the Bamni hill. This mine belongs to modern times and is small, so that we most probably have here an untouched nest of rich ores.

"Intercalated between clay and quartzose slates, we find here rich ores as our experimental works have proved; massive and compact pieces of malachite, often the size of a man's head, occur frequently, as also spheroidal lumps.

"From this point the vein diverges, as one part seems to stretch south of the village of Landoo, while the other strikes north of it; they converge again in the Chundroo hill.

"Following the northern vein we find some small mines near the village of Ganri, and afterwards close to our shaft No. IV. considerable works strike h. 6 to 6½.

"Then we come to shaft No. I, where there are works of very considerable extent.

"Everywhere we find rubbish and yellow clay slates and quartz in which malachitic ores with a large percentage of iron occur.

"We opened one of these old workings by shaft No. I and sunk to examine the strata, and thus we found in a greater depth sulphurated ores with the malachites. The strike is h. 6 to 7.

"Further east we come to the Chundroo hill, and before describing this I shall return to the southern branch of the vein.

"We first find a hill, Lombapahar, on which there are some old mines, which we have opened again by our shaft No. VI. These are very considerable and strike h. 6½ to 7.

"Springing out into the plain we find some old mines near our shaft No. II, strike h. 6, and then nothing further up to the Chundroo.

"The old workings near No. VI are very considerable, and the ore mostly appears in ellipsoidal lumps in a silicious and talcose matrix, but it also forms threads and bands in the slates. These old mines showed in the beginning only leaves of malachite, but as soon as the firm quartz rock was broken, it was found that it had protected the ore, and the sulphurated ores appeared at once.

"Here also the ores are rich in iron.

"The mines on the Chundroo are very extensive.

"The Chundroo is a conical hill, and on its top we find both veins lying near each other, and the two veins I have described seem therefore to be a bifurcation as mentioned before. The circumstances are identical with the mines No. VI, and the Ancients seem to have worked only the ellipsoidal masses leaving large cavities coloured green by the action of the air.

"The strike is not constant here, but seems principally to be h. 6½ to 7.

"Further east on the plain we find the Charratungri where small heaps of rubbish of a quartzose character are found; then the Balooktungri, also a small hill, where we find malachitic ores rich in iron in a green slate.

"Then we come to the Bankatungri, where we find a totally metamorphosed and calcined quartz permeated by threads of sulphurated ores, and the black oxide of copper. Everything appears confused here, and in going deeper this rock soon disappeared, and a talcose rock was found underlying. In the plain itself we find old workings near Matkoo and Hitkoo. Both places show nearly the same character, quartzose slates containing ellipsoidal lumps of ore composed of copper and iron.

"Generally the iron is predominant as in Hitkoo just now. The experimental works at Matkoo show very fine copper ores.

"The strike is h. 7 in Matkoo and h. 7½ in Hitkoo.

"We then come to the Rangamutti, a spur of the Rangipahar (pahar, mountain) where considerable mines are met with, showing the same feature as mine No. 1 in Landoo. Strike h. 7½.

"The first mines we meet after this are on the other side of Nichua on the Raka and Bagkara hills; the first mentioned are trifling, the others extend over two miles. A low long hill in the middle of two parallel ranges contains the lode which has been worked by small shafts and level pits.

"The predominant rock is a quartzose sandy slate often rich in mica, talc and chlorite. The mica is often coloured black or dark. The ores found are leaves of malachite and not unfrequently threads of sulphurated ores, as well as the black oxide of copper, strike about h. 8. Nearly the same conformation is shewn by the Gawai Sal hill encased by parallel

higher ranges. Here the quartzose slates predominate, and the whole hill is perforated by old workings. The strike is h. 8.

"Further east separated by mountain gorges are the old mines on the Sookoona hill in the immediate neighbourhood of the Sherdishur hill. The strata are micaceous and sandy slates, sometimes chloritic slates, but even here the quartz predominates.

"The ores are leaves and incrustations of malachite.

"Following the hill in an easterly direction we come to very extensive old mines. A gorge descending from the Sherdishur mountains has broken the vein nearly in the direction of the dip and laid it bare east and west. The Ancients had got up very considerable works in this gorge. With the slates we find quartz to predominate ; the ores found among the rubbish are incrustations of malachite and sulphurates. The hill east of this gorge, the Bindabun, is the highest of several terraces descending from the Sherdishur hill.

"It is not only remarkable for its old mines, but for another terrace lower still, called Roamghur, where the remains of ditches and buildings are found as well as a quantity of slag. According to local tradition these ruins are the remains of the stronghold of Rooam Rajah, who worked the mines and smelted copper.

"Further east we find the old diggings of Paharput (near Neturghat) showing the same strike as the Bindabun hill, *viz.*, about h. 8.

"From this place, the culminating point, Sherdishur, the strata strike more south.

"The Sherdishur mountain itself is the result of an E. and W. elevation intersected by a N, and S. one, and the rocks are often metamorphosed, and here, as well as on the Bindabun, we find basaltic jasper.

"After a long interval we come to the old mines on the Pattertungri. This long stretched hill is cut off by a N. and S. elevation at its western end and disturbed by a similar one at its eastern end.

"It is fully 20 minutes long and is composed of slates, rich in quartz, in which the Ancients have made large mines by galleries and shafts and even open working.

"The ores are the usual concretions of malachite and the strike varies from h. 8 to 10.

"In the western parts the mines seem to be in chloritic and black mica slate.

"Further east the hills draw more south and fall therefore back, but as the strike remains constant, the vein of course falls into plain.

"Here again we probably have a bifurcation as a branch goes south of the village of Pathurghurra, and another north of it from the village of Surda, Both shew black mica slate, and the northern branch often shews in addition signs of metamorphic agency, and also contains garnets, hornblende and felspar. The samples of ore found on the heaps of rubbish were incrustations of malachite.

"The strike of the southern branch varies from h. 9 to 11, while the northern varies from h. 1 to 9; both coincide in the very extensive workings from Baragoria to Badea. The latter mines being completely in the plain are open workings mostly of extraordinary circumference, but all covered by earth and refuse to such an extent that the standing rock can nowhere be seen.

"By the direction of the immense heaps of rubbish the strike seems to be about h. 10, and the rock is clay slate and quartz identical with the rock at Landoo with the same ores. These heaps stretch along the plain for more than two miles.

"I must mention here a curious instance of the contortion of the strata caused by S. and N. elevation.

"Black mica slate and silex are the rocks in which the ores appear near Karrapatter hill, but they are disposed in a semicircular form as they strike gradually from h. 6 through 10 and 12 to h. 1. The rocks are metamorphosed, and the quartz appears calcined as on the Bankatungri near Hitkoo.

"We have now arrived near the plain of Badea, copiously covered with alluvium, and we lose the old mines, but we find them again, though small, on the other side of the valley, where they are cut off and much disturbed by S. and N. elevations.

"I have not surveyed the country from this to Bairagoora, but in the neighbourhood of that village on the left shore of the Soobunreeka, heaps of rubbish and ores have been found, and I heard that there are the remains of old furnaces on a plain near the village. At all events it will be necessary to investigate this country thoroughly next winter.

"Though some of the mines enumerated are of very little importance, others are much more important, and the cursory enumeration shows sufficiently that the rich mines have been plentiful.

"The most important fact to elicit beyond doubt was whether the Ancients had worked all the rich nests, or whether they have left many untouched.

"The discovery in Jamjori, which certainly falls within a recent period, proves without doubt that very many untouched nests exist; and, though it has not been possible yet to search for such sites under the alluvium of the plain, the probability is very much in favor of our finding them there also.

"By opening the old mines we soon proved that the Ancients had seldom gone deep, and the very important question rose whether the vein was only metalliferous in its upper part, or whether the ores went deeper than the Ancients had been able to go from technical reasons.

"Mining operations alone could decide this point, and I chose the neighbourhood of Landoo last year as one of the most favourable spots to test this.

"No trained miners being procurable among the population, I was obliged to execute all the works by these country people, an entirely rude and semi-savage set. Notwithstanding this we have already arrived at positive results, and as we have since the 7th February last imported some German miners, with their aid we shall now advance more rapidly.

"The results we have obtained up to this time in shafts Nos 1, 4, and 6 in Landoo and Mutkoo are as follows :—

"I spoke of No. 6 before, and on our first examination it seemed as if the Ancients had taken out all the rich ores, but in breaking down some of the pillars consisting of hard quartz we found they contained good ores. This proves that the Ancients only took out what their simple means

allowed them, for the quartz could only be effectually worked out by blasting which at that time could not have been known to them.

"In No. 4 we have not yet reached the ore which has been extensively worked in a hill in the neighbourhood, though we ought to have fetched it according to calculation. We therefore have here a dislocation of the strata.

"In No 1 we sunk through firm rock after having reached the end of the native workings, and after having gone through rock which showed no ore we reached deeper down a very fine and rich vein, the examination and opening out of which is in active progress. Below this nest the vein became poorer, and mining alone can prove whether we have a richer part below again or not.

"Thus we have shown that the vein reaches deeper than the Ancients were able to go, and that mining operations throughout the property alone can prove whether the vein reaches very great depths or is only superficial work, which, under all circumstances, will require some time.

"By analogy of most occurences of copper ores we may however fairly expect that the deeper we go, the better they will become, particularly where they are out of the reach of decomposing influence, and will be sulphurets and perhaps copper pyrites.

"It is therefore of the greatest importance that these works be continued with energy, as the extent of the mines will mainly depend on these examinations, and this is the more desirable, as there is already opened out fully enough ores when mined and smelted to meet much of the outlay hitherto enhanced in this undertaking, as also to pay current expenses at present. This will be shown by the following calculation.

"The normal state of the vein seems to be 18 to 24 inches, and when so it is richest, sometimes it becomes three and more feet in size, but in such case the ores are more scattered in it and the vein is not so rich.

"Where rich nests occur, and they fall within the influence of decomposing agents, the whole of the vein is more or less decomposed, and contains copper all through. Analysis has shewn an average of 8 to 9 per cent. of copper in the whole mass. Taking it at 6 per cent. we are at all events not taking too much. In no places where the ores are more removed from such altering influences by no means the whole mass con-

tains copper, and the ores can be easily separated from the rock, and we then find that ½ or ⅝ of the mass remains with 10 to 15 per cent. and more of copper.

"The separation of the ores from the stone is at present done by hand, and gives the following qualities of ores in about the proportions mentioned :—

1st sort,	30 per cent.	about	¼th part.
2nd	20	ditto	1 ditto.
3rd	10	ditto	2 ditto.
4th	7	ditto	4 ditto.
5th dust	5	ditto	2 ditto.

Average 9 per cent. as the analysis of the whole also shows.

"Besides this we have the mud remaining, which often contains a good deal of ore, and which can only be made available when we have machinery to wash it, and therefore is not counted, as well as the very poor ores of 1½ and 2 per cent. which are not thrown away but put in heaps in case they can be used hereafter.

We have now ores of 8 per cent. prepared for smelting in round numbers ..... cwt.	950
Ores not prepared amounting at a low estimate to 7,000 cwt. of 6 per cent. deduct ¼ to make them 8 per cent. ... cwt.	4,630
Total cwt.....	5,580
In Shaft No. 1 we have now opened out at a very moderate estimate ..... cwt.	12,000
And we are opening out every day more.	
In Jamjori, where we are working energetically to open out the rich block of fine ores, we can easily take out three or four times as much in a short period..... say cwt.	36,390
Total at 6 per cent ..... cwt.	48,000
Or taking off ¼ for stone at 8 per cent.	32,000
Add from prepared and unprepared ores as above	5,580
Of 8 per cent..... cwt.	37,580

which will yield at least 2,500 cwt. of metal, if even we take the loss in smelting at 16 per cent., and this production will no doubt go far to cover

the outlay made. Should these nests prove larger than this very moderate estimate makes them, or should we find deeper, or in other places below the alluvium such places as there is every promise of, we shall have secured a great success and a certain very large return.

"Having now sketched the traits in outline of this copper formation, and all that I have been able to glean in regard to it, I conclude by stating that mining here never will have to contend with any great engineering difficulties.

"The rock is mostly strong and wants little timbering, and on the whole we have little water. The only difficulty we have to overcome is the forming of good miners and smelters.

"My experience of eighteen months in this country shows me that the native labourers we have, though not bad for earthworks, have little bodily strength and endurance, and must be constantly superintended.

"To this I may add that these people never will become independent workmen, one of the first requirements of a miner.

"If even we could overcome the dislike of these people to work steadily and without intermission, I do not think they will ever be fit for work in the mines, or smelting furnaces except as understrappers, for we would be obliged to put an overseer over each work.

(In Europe each overseer has 30 to 50 men under his control).

"It would most probably be too expensive to get out Europeans for the entire requirements of the mines, and for this reason I beg to submit the proposal whether it would not be advantageous to get a number of Chinese coolies who certainly would be good workmen ; but all the captains and overseers should be Europeans."

Finally, there follows a *Report on the Copper Ores of Singhbhoom*, by R. Schenck, Esq., Smelter and Mining Engineer, late of Freiberg.

"It is only lately that I have begun to make experiments for smelting the copper ores of the mines near Landoó, and of course nothing definite can yet be said about the most advantageous process on a large scale until

my furnaces are built, but the following will show that no difficulty exists in the way of smelting the ores.

"My experiments were made with the ores prepared for smelting in Landoo and comprised 8 kinds of ore, *viz*,—

No. 1,	containing	35·03	per cent.	copper.
2,	,,	21·27	,,	,,
3,	,,	10 40	,,	,,
4,	,,	7·37	,,	,,
5,	,,	5·60	,,	,,
6,	,,	4·98	,,	,,
7,	,,	2·03	,,	,,
8,	,,	1·46	,,	,,

"Of these ores only No. 1 contained sulphur enough to be smelted for a matt. In the other ores the proportion of sulphur is too small to obtain a matt which would contain all the copper and iron.

"I therefore tried to produce black copper at once.

"Mixing the ores Nos. 1 to 4 in equal parts, I got a sample containing

Copper	20·7	per cent.
Sulphur	0·2	,, ,,

and smelted it for black copper. I invariably got black copper of a pure quality and free of sulphur.

"It is evident that these ores must be treated as carbonates or oxides, and that black copper must be obtained by the first process, which has only to be toughened afterwards to have malleable copper.

"Only experiment on a large scale can decide the particulars to be observed when our regular production begins. Modifications, perhaps even a wet process, may be necessary then, but no real difficulty exists."

Specimens of the ores were submitted to Dr. Oldham, then the Superintendent of the Geological Survey of India, who writes—

"I have carefully looked at the specimens you sent from the Copper Mines at Dulbhoom. They are decidedly promising. The ore from the

upper levels is a kindly gossan with strings of the carbonate of copper and and grey copper through it; the other from about 35 fathoms from surface is a quartzose matrix with green carbonate and grey copper abundantly disseminated. To give an opinion of the value of a mine or the prospects of success in further exploration from hand specimens is quite impossible; but such indications as these specimens afford fully justify a very extended and perfect exploration of the locality, and certainly give promise of RICH ORE.—*Calcutta, 12th May* 1857."

1860-64. Emil Stoehr. Copper Mines, &c., in Bengal.

Three years later, Dr. Stoehr contributed two papers on the same subject to the *Vierteljahrschrift der Naturforschenden Gessellschaft*, in Zurich, V., p. 329, and in the *Neues Jahrbuch fur Min. Geol. u. Pal.* 1864, p. 129; an abstract translation of which is given in the Records, Geol. Sur. of India, III., p. 86, and from which the following extracts are taken :—

"*Copper ore : its range.*—This copper ore would be interesting if only on account of its unusual longitudinal extension—for 80 miles if not more. I have examined it more closely through a length of 65 miles, from Lopso hill in the west to as far as Badia in the east. I know nothing of its further distribution in the western forest-clad hills, but in its eastern range it goes far beyond Badia to Bairagurha, the most south-east point on my map; and so far as I examined the intermediate hills, traces of the ore were found everywhere; but in its longitudinal range, it appears most in the northern hills.

"*A lode, or bedded.*—The strike and dip so coincide with those of the containing strata that one is induced to consider the mineral deposit as stratified; against such a supposition there is the vein-like mode of deposit, the frequent cuirasses and slickensides, the occurrence of druses, and the broken outcrop. At all events the deposit is a filling of cracks parallel to the layers of the containing rock; and the formation of these cracks was probably contemporaneous with the upraising of the schists. Following the structure of the containing rock, the deposit was originally variously irregular; and this condition was aggravated by the intrusion of the diorite.

"*Several outcrops.*—Proceeding from north to south there frequently appear two or even three consecutive runs of copper ore; it would thus seem partly that one and the same band was brought several times to the surface by upheavals, partly that a system of parallell deposits truly exists. At all events we can recognise at several places two parallel ridges, or lines of outcrop, sometimes miles apart, sometimes coming so close that they almost commingle. Going from west to east we find, quite to the west, near the Lopso hills, two runs of ore scarcely ten minutes from each other; a third more northern locality seems only due to a local disturbance. These two runs separate to eastward, being several-miles apart at Khursowa, until they appear to come together again in the Akarsuni hill. From there to Tamba-dungri (copper hill) the deposit is buried beneath the deep soil of the plains. At Tamba-dungri one run appears which can be traced over Jamjura, then bending southward to Landu, and then again northwards to the summit of the conical hill Chundra. A little north from Jamjura a second band shows, which runs northwards from Landu to Chundra, at the summit of which these two runs are scarcely two fathoms apart. From here the two separate again, one goes south to Matku in the plain, where it is concealed; one to Hitku, Banka, etc., in the north flanks of the Rangi hills. Here there is a break of several miles where I was not fortunate enough to find the ore: finally, it appears again at Racka and proceeds then in a long line following the north hill-flank. Between Bindrabun and Sideshor the strike alters, from east-37°-south to east-60°-south; also the intruding diorites disturb the rocks much, and with them the deposit. In their further course eastward the hills trend rather back, and the deposit gets gradually into the plains. At Pathur-ghora, we find again two lodes, probably, however, only the broken parts of the same main lode which unite at Bairagurha. From here all goes straight, except once at Karapathur there is a disturbance; the contorted and crushed strata are confused and the rock almost altered into gneiss. These schists are stuck up to north by a south to north upheaval, and twisted round the Karapathur, till at last all becomes normal again.

"*Varieties of the ore and gangue.*—As for the ores themselves:—when removed from the influence of the atmosphere the iron ores are mostly magnetic iron, less often pyrites: the copper ore, too, is seldom

pyrites, mostly glance-copper and red copper ore; either ore indeed is seldom pure, but mostly the two in intimate variable mixture, so they almost form a peculiar ore of blue-red colour, soft, and with red streak. According to several analyses (among others by Fresenius and Roth of Heidelberg) the proportion of sulphur varies from 9 and more per cent. to complete absence; and also the total of copper from 42 to 64 per cent.; the ore is always contaminated with iron, from 5 to 12 per cent. It seems that when sulphur is quite absent, glance-copper is also wanting and the red-copper is not pure but mixed with black-copper; also in many places black copper occurs in strings and disseminated, and is used by the native beauties as a black dye for the teeth. Beautiful rosettes of red-copper appear detached, no doubt the result of decomposition. In the upper levels the saline ores occur as the result of alteration; malachite, less often azurite, and brown spar. The whole gangue and ore are often so decomposed that these products are formed to a depth of 15 fathoms. As a ternary product of decomposition, on the heaps and scattered, I may mention chrysocolla, libethenite, and chalcophyllite.

"I must again notice the intense atmospheric action; often at the depth of 30 running fathoms the decomposition had not ended; the earthy quartzite-schist had become decomposed and penetrated with malachite and brown iron ore.

"*Malachite*, in solid masses, compact and earthy, seldom fibrous; in the upper levels the only ore, where it occurs in film and fragments, or mixed with brown hæmatite, impregnating the whole gangue, which then contains from 2 to 8 per cent. of copper. It occurs besides as infiltrations in cracks and slender clefts where a rich deposit ends or begins. It is always more or less mixed with silicious earth and ochre: the purest pieces give—

Oxide of copper	54·73
Iron oxide	6·20
Water	6·87
Carbonic acid	15·15
Alumina	·83
Insoluble	15·95
	99·73

"*Red copper ore*, in solid masses from the size of a nut to several feet in diameter in a silicious matrix, sometimes filling the whole lode and enclosing angular pieces of quartz, sometimes in strings and flakes ramifying through the rock. This is the most important ore, seldom indeed pure, almost always mixed with black copper and iron oxide. As the malachite is due to the further decomposition of this ore, so is it of glance-copper; some specimens show the three states. It is difficult to find red copper entirely free from copper-glance; apparently pure red copper specimens have given 8 per cent. of sulphur. The mixture with iron oxide varies from 0·25 to 18 per cent It is too always mixed with black copper; and it was interesting to know if the proportion were constant; analysis showed it to vary from 63·7 per cent. sub-oxide and 33·6 of oxide to 50·14 per cent. of sub-oxide and 46·74 of the oxide. It is only an indefinite mixture. Often the oxide is in excess, the ore being dark brown, with black metallic streak. The common variety is brown red to cochineal red, with red streak, and in pure pieces, a fine crystalline texture. This quality, with hardness of 3, sp. gr. 5·623, gave—

Sub-oxide	63·72
Black oxide	33 60
Silica	1·02
Alumina and iron	0·75
Lime	0 64
Magnesia	0·10
	99·83

Others gave traces of manganese and bismuth.

"*Black copper* occurs only as a coating, and at most in strings as thick as the back of a knife and always mixed with red copper and iron oxide.

"*Copper-glance* massive, mostly in kernels. It is at all events the original undecomposed ore: seldom pure, almost always with iron oxide.

"*Copper pyrites* seldom found; and only sprinkled here and there.

"*Azurite* as a crust. It is remarkable how seldom it appears where malachite is so abundant; I only know of one locality.

"*Libethenite* and *Chalcophyllite*, in small crystals in the old refuse heaps; similarly *Chrysocolla*.

"*Native copper*, in massy rosettes and flakes; rare, and only where surface water can penetrate; associated with malachite, of which it seems to be a reduction and not of red copper.

"*Copper uranite* was found on Lopso.

"*Iron ores.*—Brown iron ore; in the upper levels often filling the whole lode, as ochre or as solid brown hæmatite.

"Magnetic iron in crystalline granular masses, sometimes even filling the whole lode mostly mixed with specular iron (Eisenglanz). Analyses of fragments of the old copper regulus gave traces of silver and gold, and 10 per cent. of iron. Assays made in London proved the ores to contain silver: an ore of 31 per cent. of copper gave 0·0078 per cent. of silver, one of 60 per cent. of copper gave 0·0039 of silver. The silver then cannot be principally contained in the copper ore, but in the gangue.

"*Distribution of the ore.*—Copper is not the only metal this deposit contains; iron predominates; so that one may describe the deposit as one of iron ore rich in copper. The copper contents are themselves very variable, from traces up to the richest ore. The action of the intruded diorites appears to influence the proportion of copper; they may come quite to the surface or only produce a north-south upheaval, the richest copper deposits always being in their neighbourhood. In the preponderating quartzose gangue the ores occur in leaves or threads, from paper thickness to several inches, ramifying through the mass; sometimes binding angular quartz fragments, sometimes in compact masses; often filling the whole vein. Elsewhere they show in lenticular lumps from the size of a hazelnut to that of the head, having then generally a covering of talc or chlorite in the quartzose base. Sometimes, but seldom, the quartzose veinstone fails, and contorted, crushed, broken chlorite, and talc schist enclose lumps of quartz and strings and pieces of ore. Once or twice the veinstone was quite porphyritic.

"The roof and floor of the deposit are not confined to any particular kind of rock of the metamorphic series; many different rocks occur as such,—clay-slate, chlorite-, talc- and mica-schist; but always a schist; quartz rock never occurs as roof and floor. The strike is the same as that of the rocks; in the west, from east-west to east-35°-south; in the east so much as east-60°-south. The dip is 15° to 50° to northward, mostly

20° to 36°. The normal width of the lode is 20 to 22 inches, at which the ore is richest; sometimes filling the whole vein. It often expands to three feet and over; but then the ore scatters and the richness suffers. Whether a workable ore extends, and how deep, is unknown; the ancients only worked that nearest the surface; but wherever I opened old works and went deeper good ore was found, generally after cutting through some poor ground, so that at 100 to 120 feet the ore still always held out. At the time of my departure the point at which research had been carried farthest was at Landu; there 212 feet had been reached, but already at 190 feet the ore had decreased, and at last was quite lost. Whether there only happened to be poor ground at this spot, or whether generally the ore does not extend to the deep, is unascertained: I would almost decide for the latter opinion. The deposit is of course not worth working throughout its entire extent; but rich parts alternate with poor or even with barren; to find the first was therefore the chief endeavour; and we were successful at many points in finding such rich localities.

"In the Lopso and Sirsu section the ore is associated with quartz and mica-schists.

"At Podumpur with a sandy mica-schist containing schorl.

"At Akarsuni with black mica-schist and quartzose clay-slate close to greenstone; granite also shows in the neighbourhood. The detritus on this granite is washed for gold.

"At Tamba-dungri, a greenstone that does not reach the surface seems to have raised the schists and partly metamorphosed them locally into gneiss and quasi-granite, and the ferruginous schist into jasper. The top of the hill is burrowed all over with little pits 60 feet deep.

"The northern run at Landu is in quartzose schist accompanied by mica- and chlorite-schist: the southern in mica- and chlorite-schist with associated quartz.

"At Chundra the ore occurs with quartz gangue in mica- and chlorite schist and quartzose clay-slate.

"At Matku in the quartzose clay-slate and quartz-schist.

"The northern lode at Chura-dungri and Hitku is in quartz-schist; at Pahlu-dungri in chlorite-schist; at Banka it is greatly disturbed and seems to be cut out suddenly by a mass of potstone.

"At Racka and Bagh-ghura the rock is sandy schist and quartzite, but mica-, chlorite- and talc-schist are not absent. It was here that disthene-rock was found. The ore is in a silicious schist and occasionally in mica- (black mica), actinolite- and chlorite-schist.

"At Sukurna, near Sideshor, the ore is in silicious schist, associated with mica-, chlorite- and quartz-schist. Sideshor appears to be the production of a penetrating north-south upheaval; and in its quartzites, traces of the ore found, as malachite,—a proof that many beds of the metamorphic series are cupriferous. At Bindrabun immediately under the ore is a massive rock composed of quartz and tourmaline with a little mica,—a granite formation, except that felspar is wanting; one might almost call it greisen. A run of jasper occurs close by, in the formation of which, as well as in the elevating of Sideshor, this peculiar rock may have taken part. Malachite traces are found in it too.

"At Pathur-dungri the rock is quartz-schist; but on the south-west of the hill ore occurs in mica-, chlorite-and hornblende-schist.

"At Súrda the ore is in dark mica-schist containing garnet, chloritoid, and hornblende crystals. Near Pathurghora the ore is in more or less metamorphic schist; near the village red felspar is associated, and the rock becomes granitoid.

"The distribution of the ore in the lode follows no certain order; unless one is to consider as such its constant association with quartz, which is always the preponderating gangue. From the agreement of the dip and strike of the deposit with that of rocks, one would consider it as a stratified ore, were there not much against such a supposition. I do not here allude to the cuirasses and quartz druses, but especially to the variable strength of the deposit itself, and the interruption and separations of the outcrops; which then again follow the strata and lie in many patches close to each other. The normal thickness may be about 20 inches; in rich spots it reaches 3 feet; while elsewhere it intermits, the deposit is compressed and decreased with only scattered ore, till this also disappears and the deposit can no longer be traced. All this suggests to me separate

lodes, *i.e.*, an impregnation of cracks parallel to the rocks, and probably formed at the time of their elevation.

* * * * * *

"*Mining experiments.*—In order to exhibit the special conditions of the deposits I will now describe the most important mining experiments. Special mining experiments could not be attempted over the whole area within little more than three years' time; they were limited to between Jamjura and Rangi. Landu was the centre; there were extensive old works there, and the flat ground offered an untouched field for exploration. The diggings that gave the best opening were No. 1, near Landu, in the north lode. At 7½ running fathoms we got to the end of the old workings, where the width, originally considerable, was reduced to 15 inches. There was great trouble in getting the men to continue the work; and when, among a lot of jackal bones, a piece of a human skull was found, all green with copper, great terror spread, and only the most pressing representations, that the skull must have been brought there by some beast of prey and did not belong to a man who had perished on the spot, could induce the men to carry on the work. The layer was only 15 inches from roof to floor, almost filled with rotten slate and quartz fragments, rich in iron, but almost without copper, only here and there a sprinkle of malachite incrustation. The ancients had evidently abstracted all the good ore till they came to this barren run. After a little the malachite increased, enveloping the quartz, and so ramifying through the still broken schist that it yielded from 1·8 to 4·5 per cent. of copper. The roof and floor were of chlorite-schist, quite devoid of copper save by infiltration in the little cracks. At 12-7 running fathoms strings of malachite occurred one-half of an inch thick; and the lode was 2 feet wide. From here it increased; and at 15½ fathoms an easterly drift was started that soon disclosed the most splendid ore; first malachite, then this passing into red-copper, and this again into glance-copper. This ore finally filled the whole vein, 3 feet thick, enclosing angular pieces of quartz; and also occurred in large elliptical nodules several feet in diameter lying in a gangue of silicious slate, in such number that a fine roof-face could be worked; at 25 fathoms along the drift, the lode split, one branch going southwards soon became barren, while the northern one yielded fine ore. In a northern trial drift from here

another vein was cut more or less rich in ore, and still further eastward three others. Down from this drift a small hading shaft was sunk; and here, at 28½ fathoms the ore began to decrease, and died out altogether. So far the underlie was 35°; here it rose to 60° or 70°; the thickness of the lode decreasing to a few inches; below this trouble it became flatter again and traces of ore re-appeared, till at 32 fathoms this too disappeared with a new trouble. It was in this state of affairs that the hand pumps could no longer keep under the water of the rainy season, and the progress discontinued at 12 fathoms vertical from the level of the valley.

"Four miles to the west, at Jamjura, under the alluvium of the plain, a very rich ore was cut, occurring in a very similar manner to that at Landu. At 18 fathoms the ore was still good. In a westerly direction was less rich, but continued to eastward. In a trouble of this vein the carbonaceous mineral was found; not only in quartz, but in solid malachite Here, too, was found the native copper, reduced from malachite by the action of this carbon.

"A third important locality was No. 6 of Landu, in the south lode; chlorite-schist and sandy mica-schist contain grains and nodules of quartz, often coated with talc; these are sometimes several feet in diameter. In and around these generally flattened lumps partly following the layers of the schist, partly, too, itself forming kernels, or surrounding fragments of quartz, comes the ore in threads from the thickness of a knife to several inches, thus uninterruptedly arranged in nuts and lumps, and in this manner forming the lode, 18 to 24 inches wide. These conditions obtained to 16 running fathoms, then the ore ceased, and at my departure the work was in barren rock. In the upper part the ore was all malachite, but in the hard undecomposed masses there was a mixture of red and black copper with glance-copper. The ore was besides always very rich in iron. At about 80 fathoms to the east, in a small trial pit, the lode was almost entirely made up of coarsely granular crystalline magnetic iron.

"At Hitku, in the northern, and Matku in the southern, lode, there occurred quartzose, porphyry-like gangue; and the ore predominated as nodules of oxides, with glance-copper. In neither place was it worth working, appearing to cease in depth.

"At Banka a clear-ringing, columnar, fissured quartzite is penetrated in every direction by thin strings of ore, black, with glance-copper. Sometimes it is scattered through the quartzite, giving it a porphyritic aspect; the quartz being then altered, dull, fragile as if burnt. Low down there appeared an agglomeration of quartzose talc-schist and nearly massive talc, where the lode stopped out suddenly.

"According to the results at Landu, the cubic fathom of 96 to 150 cwts. of raw ore gave an average of 6 per cent. of copper; and the cost of extraction of the same, including haulage, amounted to Rs. 22 to 23 per 100 cwts. of raw ore.

"The preparation by hand-picking must be regulated according to the proportion of saline ores; here the average of 100 cwts. of raw ore was—

3 cwts.	of rich picked ore of	..	..	20	to 35	per cent. copper.
60 ,,	average ore of	..	..	8	,, 9	,, ,,
13 ,,	dust ore of	..	..	0	,, 5	,, ,,
24 ,,	rubble and poor ore of	..	..	¾	,, 1½	,, ,,

All the poor ore was considered as rubble for crushing. In the best rubble there occurred but 8 to 10 per cent., very seldom 20 per cent.

"*Labour.*—Most of the coolies were Dhangha Kols. On the whole, they proved themselves very intelligent and skillful; on an average more so than our European workmen; only they are weaker; but whether mentally or bodily, they are very slothful, so that they require constant watching. The daily wage of a workman is 4 to 6 pice; with which they receive the powder and tools supplied; yet job-work was only undertaken by experienced workmen. The gang at one face could not amount to less than four to six men. It was impossible to get the people to work uninterruptedly, so that a face 1½ fathoms high thus worked only advanced 0·8 of a fathom monthly.

"*Prospects.*—Since 1862 great endeavours have been made in London to get up a limited company with £120,000 capital to work the Singhbhúm mines. The original company was dissolved about 1859; its history was this: after Captain Haughton in 1854, in the Journal As. Society, Bengal, had first called attention to the mineral treasures of the district, two Calcutta merchants resolved to start mines, and I went to Bengal by their instructions to make investigations and to establish the mining. When it was certified that at many places fine ore occurred, a

Company was formed in 1857, having at its head the two original firms; and everything was then started on a very great scale. Mining commenced at Landu and Jamjura, and fine raw ore was turned out at the rate of 1,200 to 1,300 cwts. monthly. Other works were at that time not yet opened and in order; still already the erection of a foundry with steam engine at a great cost was insisted on: and consequently, after my departure, what was expected, befell: there was not yet enough ore there for the supply of a large foundry; the company dissolved in 1859; and the stores, building, and machinery fell to a transferee at an insignificant price. So very costly a management had only accelerated the dissolution of the company. In India every administration is costly: here it was the case in a remarkable degree, as this single circumstance fully proves—Rs. 9,200 had to be paid yearly to the two Rajahs of Ghatsilla and Seraikela, in whose land the works were situated, for the right of mining and smelting.

"As above stated, since 1862 great exertion has been made to form a grand new company; and in the prospectus mention is made of my name with reference to my report to the former company, so I do not hesitate to declare that without further information than that already known and established—so long as nothing positive is settled regarding the continuation of the ore in depth—the formation of a company with a capital of £120,000 is unwarrantable. Ore, and very fine ore, is undoubtedly to be got; and the works already undertaken might be carried on to advantage in spite of the deficient communications, if with moderate expectations an economical enterprise be undertaken, but for this so colossal a company is not suited. If the works are to be again established, mining experiments should be extended before everything, and according to the results thus obtained such a company might be formed or not. No one could expect an exhaustive judgment from the works already accomplished, and, considering the time spent upon them, the first surface labor took place in the end of 1855, and already in 1859 all was discontinued.

"*Ancient mines.*—Almost wherever the deposit comes to-day and is not concealed beneath the alluvium one finds old buildings and refuse heaps where there was formerly a mine. In spite of the rudeness of the mode of extraction the work must be admitted to have been sagaciously

conducted. The ancients never went deep; sometimes hindered by the water which everywhere is reached below the level of the valleys, sometimes by the fear of working under ground. The use of powder in blasting must have been unknown to the people of that time, for I everywhere found in the old works, where open, single pillars undisturbed, very rich in ore, but in such hard rock as only to be won by blasting. The ancients seem to have smelted the ore in little furnaces on the spot, for one finds remains of walls, heaps of slag and even copper bloom in many places. It is impossible to determine the age of the old workings; the heaps and fallen-in-pits are mostly overgrown by thick jungle and covered by old trees; only here and there one finds large openings in the rock, at present the refuge of crowds of bats, whose dung covers the floor more than a foot deep; the cavity itself being converted into a beautiful green hall by a thick crust of malachite. If one asks the inhabitants when such work was in progress, they do not know; and they speak of 100 years with the vague ideas of Asiatics about time, representing thereby an arbitrarily long period. It seems to me, however, certain that the present half-wild inhabitants are not in a condition to carry out such works; and these may be the relics of an ancient civilization, like the rock-temples of the neighbouring Orissa, like the fruit trees (mango and tamarind) that one often finds as very old trees in the middle of the thickest forest; as again the remains of the great town Dulmi, which once stood in the thick woods of the Subanrika Only one story has reached me of the ancient mines. Where from the lofty Sideshor, the ridges of Bindrabun, Ruamgurh, and Mahadeo descend into the valleys as spurs, one finds on Bindrabun extensive old diggings and pits, and on Ruamgurh slag-heaps and remains of brick walls. There, at Ruamgurh, a rajah of the name of Ruam must have lived and have made the diggings and houses. In the story this rajah is reported to have had two tongues, so I must consider him as a person who spoke two languages, in fact a foreigner. The period may have been the 11th century, when the Kingdom of Orissa flourished."

1870. V. Ball. Copper and Lead, Manbhum.

The examination of the country was next taken up by the Geological Survey of India, when Mr. Ball's important investi-

gations came to the front in a *Note on the Occurrence of Argentiferous Galena and Copper in the District of Manbhum, South-west frontier of Bengal.* Records, Geol. Sur. of India, VI. p. 74; from which we extract the following:—

"During my geological examination of Mânbhúm, the discovery of galena or lead ore was made in the following manner:—When at Dadka, a large village forty-five miles south-south-east of Púrúlia, which is the sudder station of Mânbhúm, the *Ghatwal* brought to me a small piece of galena which had been given to him a few years before by some *Kumars*. He did not know what it was, but used some of it instead of *Surma* or antimony for the purpose of anointing the eyes of his female relatives.

"By enquiry from the *Kumars* of the neighbourhood, I was, after several failures, at length enabled to trace the source from whence the galena had been obtained. The lode, for it proved to be such, had been struck some years previously by some *Kumars* who were searching for iron on the side of a hill formed of mica schist, in which there are a number of veins or small lodes filled with brown hæmatite. This hill is close to a *dih* called Jani-jour, where there is an outlying house of the village of Dekia, which lies about a mile east from Dadka.

"I could not ascertain that the *Kumars* had met with galena in any other part of the neighbourhood, though excavations for iron were plentiful.

"Having found traces of galena on the surface, I proceeded to excavate, and soon obtained a number of fine specimens of the ore. It occurred quite independently of the bedding of the schists, sometimes in lenticular masses five or six inches long surrounded by quartz, and sometimes in a gangue principally composed of brown hæmatite and quartz; these appearances justify the conclusion that this is a case of a true lode. Owing to the excessively jungly and broken condition of the ground, I was unable, during the period of my brief visit, to trace the lode for any distance, and for the same reason I was unable to ascertain its exact width. Although, therefore, much remains to be ascertained

regarding it, still, so far as it has been examined, the indications may be affirmed to be promising. All who have given the least attention to the history of mining are aware of the capricious character of lodes, and of the impossibility of forming even an approximately correct opinion as to the value of any particular one—which is not laid open by a natural section—until some outlay for excavation has been incurred.

"With regard to the first question, the assay of some of my specimens by Mr. Tween has proved the presence of silver in the unusually large proportion of 119 oz. 4 dwts. 16 grs. per ton of lead.* The assays of most other Indian galenas have given a much smaller amount than this. In Europe, from 35 to 40 oz. per ton is considered quite above the average yield, and argentiferous galena containing very much smaller amounts is frequently worked for silver with profit.

"Mr. Tween has also ascertained the presence of antimony in combination with the lead.

"The nearest locality to this at which lead has been discovered is at Hisato in Chota Nagpúr. The antimonial galena from that locality has been described by Mr. Piddington. From the first specimens sent to him by Major Ouseley he obtained silver in the proportion of 70 oz. per ton of ore; but other specimens subsequently received did not contain a trace of silver.

Copper Ores.

"Copper ores have been discovered in two localities in Mânbhúm. The principal is situated on the crushed and faulted junction of the metamorphic and sub-metamorphic rocks about one mile north-east of the village of Poordah, Pergunnah Mánbazaar, or about thirty miles from Púrúlia.

"The rock in which the ore occurs is a coarse mica schist, which is traversed by numerous veins of quartz. Whatever the amount or quality of the original ore may have been which existed near the surface, it has nearly all been removed by natives, slight stains of the carbonates of

copper on the schist and quartz debris alone remaining to indicate the object for which the numerous excavations which occur along the outcrop have been made.

"These ancient excavations at the time of my visit were filled up, some with water, others with debris, which circumstance, coupled with the fact of the ore having been removed, rendered it difficult to form a decided opinion as to the precise nature of the deposit. Subsequent examination of the numerous and often well-exposed copper ore deposits of Singhbhúm, which appear to be of mixed character (generally the ore occurs disseminated through regular beds of schists ; but departing from this rule, it occasionally occurs in true lodes), has induced me to believe that these ill-seen Mânbhúm ores also occur in a two-fold manner. It is possible that the copper-bearing beds of Mânbhúm may belong to the same Geological Zone as those of Singhbhúm ; but there are arguments against, as well as for, this view. The whole question must be treated in greater detail than is now possible.

"The second locality at which copper occurs is near the village of Kulianpúr, or about thirty-two miles due west of that just noticed. It is on a small hill formed of schists and quartzites, which in one place are stained and encrusted with the carbonates of copper. There is an ancient excavation on the south flank of the hill. So far it is possible to judge, the deposit seems similar to No 1. It is not improbable that the ore may be found further westwards, but I did not succeed in obtaining any trace of it in the section exposed in the Subanrika river. There is a small quantity of slag at the bottom of the hill, which indicates that the ore which was found here was smelted on the spot.

"The small indications of ore to be seen at the two localities mentioned above are certainly not sufficient to justify any expenditure for excavating, more especially as the attempts to work the similar, but vastly more extensive copper deposits of Singhbhúm, have not hitherto proved to be remunerative speculations.

"Various rumours of the occurrence of ores of tin and copper in different parts of Mânbhúm have from time to time been promulgated ; but the supposed ores of the more valuable metals have generally proved to be either some form of iron ore, the green mineral epidote or a bronze-coloured mica."

A further paper by Mr. Ball, *On the Copper of Dhalbhum and Singhbhum*, in the Records Geol. Sur. of India, Vol. III., p. 95, gives the following information :—

"The copper ores to which this account refers occur for the most part in a zone of schists whose geological position is situated near the base of the sub-metamorphic rocks. These schists form the northern flank of a broken spur of hills which leaving the Chota Nagpúr plateau strikes eastwards for a distance of 40 miles through the estates of the rajahs of Khursowa, Seraikela, and Dhalbhúm, then bending round gradually to south-east and ultimately to south, it disappears under the alluvium of Midnapur.

"The principal ranges composing this spur are of quartzite, upon which incrustations of the copper salts are occasionally found ; but the ore which has been worked is, with a few exceptions, to be noted hereafter, associated only with schists.

"Measured along the strike, these copper-bearing rocks extend for a distance little short of 80 miles. Copper ores have not been discovered west of Lopso ; but there is no geological reason why they should not be found for many miles further in that direction in the Chota Nagpúr highlands.

* * * * * *

"The determination of the question as to the manner in which the copper occurs, whether in lodes or as a deposit, is one of no less difficulty than it is of importance. M. Stœhr holds the opinion that it occurs in lodes, though admitting that much may be said in favor of the opposite view. He describes the variable strength of the deposit itself and the interruption and separation of the outcrops which in some places are close to each other. Carrying out this view, he distributes the localities where ore occurs along two lodes which he calls the north and south. He alludes to the fact of the existence of particular beds of rock in the vicinity of the copper showing signs of excessive metamorphism which he considers to be due to local action ; but he does not mention that the copper, if followed along its line of strike, is found to penetrate into areas occupied by rocks which are undistinguishable in their lithological characters from the most crystalline rocks occurring in the older series, Of

course it may be that these, like the single beds above mentioned, have been affected by local metamorphism, possibly caused by the intrusion of granite, but the granite which occurs is not distinguishable from that which is often found in Bengal to alternate with well foliated rocks, and is therefore believed to be of metamorphic origin. Thus this circumstance, which might otherwise be used as a crucial test of the validity of the lode hypothesis, is itself so uncertain and fraught with doubt that it is a rather dangerous description of evidence to make use of in such a discussion.

"In support of the view that the copper partakes of the nature of a mechanical or chemical deposit in the beds, there is the fact that the underlie of the ore as seen at the surface nearly always appears to correspond with the dip of the schists, and that sometimes the schists appear to be permeated throughout with the ore. Adopting this view for the moment, the following supposition would appear to afford a possible explanation of most of the phenomena with regard to the ore, which have as yet been observed. With the original materials of the sandstones and mudstone shales, which subsequently become metamorphosed into schists, the ore may have been either chemically or mechanically deposited. At some period the crushing and tilting up of the rocks, of which there is abundant evidence, produced cracks and possibly openings between adjacent beds, towards which a segregation of the copper particles which until that time were equally disseminated throughout the mass of the schists may have taken place and continued until they became filled with ore and so given rise to the appearances which have been regarded as indicating the existence of lodes. If this view be correct then the highly metamorphosed rocks which occur in the otherwise uninterrupted strike of schists at Akarsuni and Kamerara must be derived from the schists by excessive local metamorphism. But if, on the other hand, these rocks belong to the older metamorphics which they certainly at first sight appear to do, then the lode hypothesis must be admitted to be true.

"Reviewing the evidence on both sides, the legitimate conclusion to be drawn would seem to be that the copper of Singhbhúm in all probability occurs both in lodes and as a deposit disseminated throughout the materials which compose the schists. Similar cases of double conditions of occurrence are not unknown in other countries, as will be alluded to again further on.

Ores.

"The ores of the upper part, or, as it is technically called the 'back' of the deposit, have all been converted into carbonates and oxides.

"In assays made upon eight different qualities of ore by M. R. Schenck, and quoted in the Hindostan Copper Company's prospectus, the contained copper varies between 35·03 per cent. and 1·46 per cent. Three analyses by Messrs. Phillips and Darlington of specimens of carbonates give the following results:—

No. 1.—Copper	31·5	per cent.	Silver	2oz.	5dwts.	17grs.	per ton of ore.
No. 2.—	,,	6·26	,,	,,	1	,,	2	,,	20	,,	,,	,,
No. 3.—	,,	6·0	,,	,,	0	,,	19	,,	14	,,	,,	,,

"Three other specimens were examined by Messrs. Howard and Dollman and gave the following results:—

No. 1.—18·8 per cent. of copper.
No. 2.—21·8 ,, ,,
No. 3.—24·0 ,, ,,

"Three specimens brought by me from Jamjura yielded according to Mr. Tween's analysis—

No. 1.—Jamjura ore, copper =52·0 per cent.
No. 2.— ,, ,, =44·5 ,,
No. 3.—Dugni ,, =36·5 ,,

"Nos. 1 and 2 were picked specimens, but No. 3 was the ordinary ore to be found at Dugni.

"Messrs. Henry Bath & Sons, to whom some of the ores, smelted to a regulus, were sent in 1854, reported as follows:—"Our assayer has carefully tested the samples thou sent us; they contain about 50 per cent. of iron which makes them very difficult to smelt, and is also very prejudicial to their sale; we think, however, that the prices affixed to them may be obtained."

No. 1.—Copper,	42	per cent.	£ 37	per 21 cwt.
No. 2.— ,,	41	,,	35·15	,, ,, ,,
No. 3.— ,,	39	,,	34·2	,, ,, ,,
No. 4.— ,,	36	,,	31	,, ,, ,,

"The assays above quoted were of the carbonates or of grey-copper.

"*Copper pyrites* occurs in the schists at Rajdoha; it was first found there by the second company; fragments of rock permeated with it are still to be found in the debris. It seems to have been little affected by the weather.

"Some of the manufactured copper was thus reported on at the Calcutta Mint :—

"'Three slabs weighing about 139 lbs. ; these were subjected to lamination and proved to be suited in all respects for purposes of coinage. The quality of this metal is excellent, being scarcely inferior to the best, equal to the average and decidedly superior to several shipments of imported copper.

(Sd.) 'R. BAIRD SMITH,
Mint Master.'

"As it is almost impossible at the present day, without excavating in the mines to a considerable depth, to obtain more than a few specimens of the carbonates or oxides of copper which lie near the surface or incrust the walls of the galleries, it is most fortunate that we are able to avail ourselves of Mr. Stœhr's researches and opinions. His presence during the mining operations and subsequent examination of the ores in Europe have afforded him the most favorable opportunities for ascertaining the precise nature of the ores obtainable in the deep mines.

"It may be taken as a fact fully established by the analyses quoted above, that exceedingly rich ores of copper do occur in Singhbhum. Before proceeding to the discussion of the practical question in reference to the possibility of working the ore with profit, it is necessary to allude to the—

METALS IN ASSOCIATION WITH THE COPPER.

"It is a matter of the greatest importance to ascertain the proportion of other metals which ordinarily occur associated with the copper. Supposing the ore even not to contain a sufficient quantity of copper to make it pay to extract it alone, it might still, if it included precious metals, be worked with profit. Such is the case with the argentiferous ore or Fahlerz from Eisleben in Prussian Saxony.

"In the assays of three specimens of ore by Messrs. Phillips and Darlington quoted above, the ounces of silver per ton of ore vary between 1 and 20¼. M. Stœhr found traces, but only traces, of gold and silver ; while Mr. Tween did not obtain even a trace in some ores and smelted copper which I brought from Jamjura.

"Small quantities of Bismuth were found in some of the ores.

"Having in the previous pages pointed out the two-fold manner in which

the copper ores occur—both in lodes and in beds—and their quality, the discussion of the practical question whether the ores are such as can be worked with profit in this country may now be entered upon. The facts and collateral circumstances which must influence a decision may be grouped under the following heads :—

I. Character of the ores and their mode of occurrence.

II. Experience of previous miners, ancient and modern.

III. Local circumstances.—Position of mines; Means of communication and distance of marts; Supplies of labor, fuel and lime; Proprietory; Climate.

IV. Comparison with other countries where ores of similar character, and occurring in a similar manner, have been worked.

"I. Although rich ores exist, their mode of occurrence is so capricious and uncertain that working them must necessarily involve an enormous expenditure.

"Ores of very much inferior quality if they occurred with a continuous unbroken lead which could steadily be followed up by the miners might, even under various unfavorable conditions existing in Singhbhúm, be worked with profit.

"M. Stœhr distinctly speaks of good ore having been found at many points, but in nearly all cases an unusual richness of the deposit proved to be purely local and confined to nests which were speedily worked out, and unremunerative copper-permeated schist met with further down.

"II. Many of the ancient mines have been so thoroughly worked out that it is often impossible to find more than mere particles of carbonate incrustations.

"It may be argued with an apparent amount of plausibility that the ancient mines, their number and extent, indicate a prosperous condition of the industry at some former period. We do not, however, know under what circumstances they were worked In the early times to which they seem chiefly to belong, copper may have possessed a value relative to the precious metals much higher than it does at present. And, again, although it may have paid parties of natives to work with their simple furnaces which could without loss be relinquished when the supply of ore failed and others be erected in a new locality, we cannot feel assured that

it would prove proportionally profitable to a European Company, whose chief prospect of success would depend on the possibility of applying machinery for the extraction and reduction of the ore continuously in one place.

"With regard to the experience gained by the companies, beyond M. Stœhr's and M. Durrschmidt's papers, there seems to be now no accessible information. Without being able to refer to the records of either of the companies, it is impossible to form any estimate of what their working expenses amounted to.

"Copper was manufactured during the time of the second company and forwarded to Calcutta, but what proportion its price in the market bore to the cost of its production I have been unable to ascertain.

"M. Stœhr's opinions on the first company and on the proposition to form a second are printed herewith. He concludes that notwithstanding the disadvantages, some of the old mines might be worked profitably, but for that purpose so colossal a company* was not suited. But *moderate expectations*, such as M. Stœhr speaks of, are not generally sufficient to attract speculators and capitalists; and a really economical enterprise such as might easily be carried out on the continent of Europe is scarcely practicable here.

"III.—Local circumstances.—*Position of Mines.* On all sides the range in which the copper ores occur is surrounded by broken hilly country, which is drained by a number of rivers of sufficient dimensions to seriously impede traffic during the rainy season.

"The only made road in the vicinity of the mines is the one between Chaibassa and Midnapur. It is unprovided with bridges: the portion of it in Singhbhúm and Dhalbhúm alone is (May 1869) in fair condition.

"In reference to the roads, Colonel Haughton, who was anxious to represent the prospects of a mining enterprise in the most favorable light possible, wrote:—"From the diggings at Kumerara† there is a good road "only 85 miles in length to Tumlook. The distance from Landu or Jam-"jura to the Cossye river at Dhee Kulliánpúr is about 70 miles; and that "river might, it seems probable, be available for water carriage during

* The capital of the 2nd or Hindostan Copper Company was £120,000 in 24,000 shares.
† The most eastern locality.

"short periods in the rains, as the Damúda is at points far above those "where it is ordinarily navigable. There is every facility for the con- "struction of a good road to Dhee Kulliánpúr or to Midnapur, and in "fact there was formerly a Government route in nearly the same direction. "* * * The distance from Tumlook *viâ* Midnapur would be about 132 "miles." The copper which was made in 1862-64 was not despatched by either of these routes, but *viâ* Purulia to Ramganj, the distance of which place from Landu being 130 miles, and the roads little better than cart tracks.

"Should the proposed direct line of railway *viâ* Midnapur to Bombay be opened up, the copper mines will probably be rendered much more accessible than they are at present.

* * * * * *

"*Lime.*—The only lime which was used for fluxing the ore was manufactured from 'kunkur.' No hope of any more regular or economical source can be held out at present. Some calcareous schists do, indeed, exist near Chaibassa, but in them the quantity of other minerals mixed up with the carbonate of lime is so great as to make it doubtful whether they could be successfully burnt for lime.

"*Proprietory.*—Singhbhúm proper belongs to several members of the Porahat family, of whom the principal are the Koer of Seraikela and the Thakúr of Khursowa; they both give service to Government as Magistrates, but pay no tribute whatever for their estates. The Dugni Baboo in whose lands copper also occurs is a cadet of the same family.

"In the estate of the Rajah of Dhálbhúm, the remainder of the copper localities, including those at Landu and Rajdoha, are situated.

"The first company, confident in the productiveness of the mines, agreed, according to M. Stœhr, to pay the Rajahs of Seraikela and Dhalbhúm Rs. 9,200 for the right to mine. In the prospectus of the second company the annual rent is stated to be Rs. 4,500. A considerable portion of this rent for the years while operations were being carried on is still due. Acting on a decree of the Singhbhúm Deputy Commissioner, the Rajah of Dhalbhúm has seized the houses and engine of the company at Rajdoha; but the former have already fallen to pieces, and the latter uncared for and neglected will soon become worthless.

COPPER ORES

Proprietors.	No.	Localities East to West.	Number of Mines.	Nature of Mines.	Dip or Underlie.
Rajah of Dhalbhum.	1	Madhopur, 3 miles north of Kumerara.	2	Outcrop excavations.	...
	2	Hills, W. of Asunbuni.	Numerous.	Ditto ...	40° E. N. E.
	3	Hills, S. E. of Badia.	.....	.....	...
	4	Badia	Very numerous ...	Ditto and shafts.	40° to E. 25° N.
	5	Mosabuni	Numerous.	Outcrop excavations.	Ditto.
	6	Surda	12	Ditto .	?
	7	Hills, W. & W. N. W. of Surda.	Numerous.	Quarries, shafts, inclines.	40°
	8	Hills, W. of Teringa and Kendadih.	Ditto ...	Outcrop excavation & inclines.	30°.35° E. N. E.
	9	Sideshur Hill, S. of Ruam.	3 or 4	Ditto and shafts.	35° N. E.
	10	Mahadeo Hill ...	.....	.....	...
	11	Baghghura	Several ...	Inclines ...	...

OF SINGHBHUM.

No.	Ore.	Rock.	Remarks.
1	Traces of carbonate a specimen yielded according to Col. Haughton 24¾ p. c. of copper.	Quartz and black mica-schist, strike 10° E. of N., granite close by.	These mines are full of water, to remove which and renew excavation would be necessary before the condition of the ore could be ascertained.
2	No traces of ore *in situ*.	Black and grey mica-schists.	Slag close by, indicating that ore was once found.
3	.....	.....	This locality is given by M. Stœhr.
4	Traces of carbonates abundant.	Grey and black mica-schists, strike 25° W. of N. Towards Mosabuni gneissose rocks strike more to north.	The relative positions of the Badia excavations indicate four distinct outcrops of ore. The principal of these passes through the village of Badia, near which are great heaps of slag. This was evidently a centre of extensive operations.
5	Ditto.		
6	No trace of ore at present exposed.	Schists.	
7	Incrustations of the carbonates on the walls.	Black mica-schist ...	From the abundance of slag it would appear that here, as at Badia, considerable quantities of ore must have been smelted by the ancients.
8	Traces of carbonates rare.	Mica-schist.	
9	Ditto slag abundant.	Ferruginous mica-schist.	At the site of the old town of Ruam, there are several tanks covered up by jungle and immense quantities of slag.
10	.....	.....	This locality is given by M. Stœhr.
11	Ditto . .	Mica-schist.	

COPPER ORES

Proprietors.	No.	Localities East to West.	Number of Mines.	Nature of Mines.	Dip or Underlie.
Rajah of Dhalbhum.	12	Hills, S. & S. W. of Matigara (=Raga of Dr. Stœhr).	Numerous.	Inclines and shafts.	N. E.
	13	Rangamatti Hill, S. E. corner, N. of Banjo.	1	Shaft ...	...
	14	Rajdoha a . .	1	Incline and adit.	...
		Ditto b	1	Incline ...	25° N. N. E.
		Ditto c	1	Shaft	Ditto.
		Ditto d .	1	Incline	Ditto.
	15	Matku . . .	1	Shaft	...
	16	Hurtopa	1	Ditto	...
	17	Hitku .	1	Ditto	...
	18	Landu Barut-ghur Hill.	Numerous.	Shafts, inclines, adit, trench.	35°—55° to 10° E. of N.
		Landu Chundra Hill b.	Numerous.	Inclines ...	35°, 55° to 10° E. of N.
		Ditto Hill, N. of Turamdih c.	Ditto ...	Ditto ...	40°—50° N. or 10° E. of N.
		Ditto Hill, N. of Tulsa d.	Ditto ...	Ditto and adit.	40° N.

OF SINGHBHUM.—(*Continued.*)

No.	Ore.	Rock.	Remarks.
12	Traces of slag abundant.	Mica-schist ...	A number of deserted pot-stone mines and some which are still worked occur along this range.
13	Traces of carbonates.	Ditto & quartzite	Incrustations of the carbonates and black oxides occur on the quartzites forming the main axis of the hill.
14	Ditto ...	Slaty blue schists .	These are situated on a spur of Rangamatti.
	Ditto ...	Ditto	These were worked by the Copper Company. But the pyrites was only just reached a short time before working was discontinued; d is west of the river, b and c being to the east.
	Copper pyrites ...	Ditto	
	Traces of carbonates .	Ditto	
15	Carbonates, traces of red copper and pyrites.	Greenish talcose schist and quartzo-felspathic grit.	
16	No ore seen ..	Quartzite.	
17	Traces of carbonates.	Schist and quartzite	Originally commenced by the ancients, it was deepened by the Company, but has subsequently become filled up.
18	Ditto ...	Quartz and mica-schist much contorted and baked Banded jaspery quartzites close by.	A considerable amount of ore appears to have been obtained here by the Company. M. Stœhr's papers give the details of workings carried on at Landu.
	Traces of carbonates.	Schist.	
	Ditto ...	Contorted talcose quartzite and micaceous schists.	These works were chiefly made by the Company, but all along the outcrop of the schists there are ancient excavations. In one place the ore permeates 6′ of rock.
	Ditto ...	Ditto ...	The mines here were worked by the Company.

COPPER ORES

Proprietors.	No.	Localities East to West.	Number of Mines.	Nature of Mines.	Dip or Underlie.
Koer of Seraikela.	19	Jeling { gora ... / bera ... }	2	Shaft and incline.	?
	20	Jamjura (*Tschamtschura* of M. Stœhr).	Several ...	Shafts .	... .
	21	Gura ...	0	. . .	. ...
	22	Tamba-dungri . .	6 ?	Shafts ...	25° N.
	23	Saldih . .	1	Ditto ...	N. N. W. 50°
	24	Múndrú ...	1	. ....	N. N. E. 40°
	25	Dúgni . .	0	0	60° N.
	26	Ukri ...	1	Outcrop excavation.	,,
	27	Komulpur (Banksai)	1	Ditto ...	?
Thakúr of Khursowa.	28	Akarsúni a ...	Several ...	Ditto ...	N. W.
		,, b . .	1	Ditto . .	?
	29	Podumpur . .	2	Ditto ..	?
	30	Regadih ...	4 (a-d) ...	Ditto ...	?
	31	Lopso Hill ...	1	Ditto ...	40° N.

OF SINGHBHUM.—(*Continued.*)

No.	Ore.	Rock.	REMARKS.
19	Traces of carbonates,	Talcose and mica-schist.	
20	Ditto and grey copper	.....	These shafts were worked by the Company; one of them fell in while the operations were going on.
21	Traces of carbonates.	Schist	No mines opened at this locality.
22	Ditto ...	Sandy and fibrous mica-schists.	Shafts in very irregular positions and without reference to the lie of the deposit.
23	No trace of ore ...	Mica-schists.	
24	Ditto ...	Soft satiny felspathic and talcose schists.	Said to have been excavated by the father of the present Baboo of Dúgni, Rungit Singh.
25	Traces of carbonates.	Mica-schists ...	This is situated in the village of Dúgni; there has never been any excavation.
26	Ditto abundant, a specimen yielded 36·5 per cent. of copper.	White talcose mica-schists and granitic gneisses.	Said to have been worked with profit by the Dúgni Baboo about three years ago.
27	Ditto . .	Schists and gneiss.	
28	Traces of carbonate.	Schists, granitic gneiss and trap close by.	A series of excavations in the fields are nearly filled up with surface soil.
	Ditto ...	Ditto,	
29	Ditto ...	Mica-schists and quartz.	Rocks much covered; no strike apparent.
30	Ditto ...	Micaceous and quartzose schists, also gneiss and trap close by (c).	Copper is said to have been manufactured from ore extracted from (d) twelve years ago.
31	Ditto ...	Coarse mica-schists.	Situated at foot of the hill west of Kanrudih.

1872. F. R. Mallet. Lead Ore, Sirgujah.

In a paper entitled—"Minerological Notes on the gneiss of South Mirzapur and adjoining country," by Mr. F. R. Mallet, of the Geological Survey, the following paragraph on lead ore in Sirgujah occurs :—

"About three miles west-south-west of Churcharee and one-and-a-half south-west of Chiraikoon in Sirgoojah, near the south-west boundary of Mirzapur, there is an abandoned lead mine formerly worked by a Mr. Burke. The rock in which it is situated is a reef of light-grey, rather shattered horny quartzite, running west 15° north, which cuts, parallel to the strike, through rotten-looking earthy micaceous gneiss. At the mine it is double, there being one band of quartzite perhaps 50 feet thick, separated from a smaller one by some yards of the gneiss, which latter is intersected by many shattered strings of quartz. The quartzite bands have a hade of 60° to south 15° west, the thicker being uppermost, and from the spots which were pointed out to me as those from which the ore had been extracted, it would appear to have occurred in two pockets ; one near the lower side of the upper quartzite band, and the other near the upper side of the lower, in both cases near the band of gneiss which separates the two branches of the reef. I observed nothing indicating the existence of a regular lode. In some specimens of the quartzite obtained from the above mentioned spots, the ore (galena) was very sparsely disseminated. Cerusite also occurs in small crystals, and I was informed by the Collector of Mirzapur that he believed antimony had also been obtained here. Of the latter, however, I observed no appearance.

1879. V. Ball. Copper and Lead Ores, Chota Nagpore.

Part III of the Manual of the Geology of India (Chap. V. p. 246) contains the following information with regard to copper ores in different parts of Chota Nagpore :—

"*Chutia Nagpur.*—In this province copper ores occur in the following districts : in Manbhum at Purda and Kalianpur ; in Singhbhum at numerous localities for a distance of 76 miles ; in Hazaribagh at Bura-

gunda; and in Palamow at Daltongunj. In all these localities the matrices of the ores are rocks belonging either to the metamorphic or sub-metamorphic series.

"*Manbhum District.*—Purda, Lat. 22° 59′ 15″; Long. 86° 37′ 45″.—About 1 mile north-east of the village of Purda or Poordah, which is in the pargana of Manbazaar, and 30 miles south from Purulia, there is an ancient copper mine, regarding the history of which nothing is certainly known.

"That the excavation was made for copper can only be gathered from the traces of the carbonates which are found on the debris scattered about. The deposit is situated along a line coincident with the position of the faulted junction of the metamorphic and sub-metamorphic rocks; and it seems probable, judging from the analogy to the deposits in Singhbhum, that the ore occurs partly disseminated in the schist and partly segregated in lodes.

"*Kalianpur.*—Lat. 23° 2′; Long. 86° 7′ 45″.—This locality is situated about 32 miles due west of Purda, and the deposit appears to be of a somewhat similar nature. There is an ancient excavation on the flank of a small hill near Kalianpur, from whence ore was probably extracted, as some stains of the carbonates are to be seen, and a small quantity of copper slag still lies at the foot of the hill, indicating that the ore was smelted on the spot.

"The occurrence of copper ores at Rajgaon, not far from Dhadka where galena is found, has recently been reported, but the statement requires confirmation.

"*Singbhum District.*—The district of Singbhum and the State of Dhalbhum include within their limits the most widely extended copper deposits at present known to exist in Peninsular India, traces of copper ores, often principally marked by old excavations, being found for a distance of 76 miles, or from the neighbourhood of Lopso, on the frontiers of Lohardaga to Kumerara on those of Midnapur. This deposit appears to exist on a well-defined horizon of the sub-metamorphic or transition rocks and close to their base; and it seems to be not improbable that the same horizon is represented to the north in Manbhum by the similar rocks

which include the just described copper ores close to and on the line of faulted junction between the sub-metamorphic and metamorphic rocks of that district.

"As a rule the copper ores occur disseminated through the schists, and the underlie of the deposit in general corresponds to that of the included rocks; but in some places the ores appear to be distributed in lodes, and the only safe conclusion to be drawn is that, as in some other parts of the world, there is a two-fold mode of occurrence, the lodes being of secondary origin and having been formed by segregation of the ores in fissures and fractures which were caused by the upheaval of the beds. If this be the true view, then the copper ores were originally deposited, either mechanically on chemically, at the same time as the other materials, and they were all together subjected to metamorphic action. Although it has been above said that the ore occurs in a zone in the sub-metamorphic rocks, there is one important exception which must not be overlooked. On the same general line of strike the character of the rocks is locally interrupted in the neighbourhood of Kharsawan, where, in a small area, rocks are found, which are lithologically undistinguishable from those of the older crystalline formation, and in them the copper ores also occur. At first, supposing these rocks to really belong to the older formation, the conclusion might be drawn that the ores must necessarily occur in original lodes, coming from the deep throughout; but, on the other hand, if the possibility of a second formation of lodes be granted as above, then by filtration and transfusion from above, these ores may have been deposited in fissures in the deeper rocks which were at one time no doubt covered over by the younger copper-bearing strata. This explanation appears a more satisfactory one than that originally suggested, namely, that these gneissose and crystalline rocks of Kharsawan might merely owe their characters to excessive local metamorphism, and were not really older than the less crystalline rocks of the sub-metamorphic series.

"Indications exist of mining and smelting having been carried on in this region from a very early period, and the evidence available points to the Séraks or lay Jains as being the persons who, perhaps 2,000 years ago, initiated the mining. The number and extent of the ancient workings testify to the assiduity with which every sign of the presence of the ore

was exploited by these early pioneers and those who followed them up to recent times.

* * * * * *

"*Lohardaga District: Daltongunge.*—During the sinking of a well in the station of Daltongunge, some traces of copper ores were discovered disseminated in beds of schistose gneiss by Mr. L. Forbes.

"The section was examined by Mr Hughes, who thought it did not give promise of a workable deposit. The ore was in four horizons, aggregating a total thickness of 4 feet 10 inches in 26 feet of section. The dip was 4°, and there was no sign of a true lode."

In the same work Mr. Ball writes regarding lead ores:—

"*Chutia Nagpur Province.*—In the province of Chutia Nagpur lead ores have been found in the following districts: In Manbhum at Dhadka; in Hazaribagh at Mahabank or Mahabagh, Baragunda, Mehandadi, Barhamasia, Nyatand? Nawada, Khesmir, Mukundganj, Parseya and Hisatu; in Lohardaga at Barikhap and Sili; in Sirgooja at Bhilounda and Chiraikund. At all these localities the rocks in which the lodes or veins occur belong to the metamorphic series.

"*Manbhum District: Dhadka*, Lat. 22° 48′; Long. 86° 36′. This name has been given to indicate the position of deposit of galema which was discovered in the year 1869. Dhadka has been chosen as it is a well known place, about 40 miles from Purulia and 65 miles from Midnapur viâ Silda, but a more precise description of the locality is that it is situated in a hill of mica schist close to a dih called Jani Jor, where there is an outlying house of the village of Dekia, about 1 mile east of Dhadka.

"The galena was found to exist in lenticular masses in quartz and sometimes in a regular gangue stone of brown hæmatite and quartz, in other words in a true lode. Recently there has been some attempt to test the extent of the lode which was first brought to notice by some kumars, who found it when searching for iron ore, veins of which occur in the same hill. The first samples of galena which were obtained yielded on assay 119 oz. 4 dwts. 16 grains of silver to the ton of lead, a somewhat exceptional amount. Traces of antimony were also noted. Exploration in this neighbourhood, which has been in progress during the present year, has

revealed the presence of one or more distinct deposits from that above mentioned.

"The following analyses are by Mr. Pedler :—

	A.	B.
Lead	79·68	69·49
Silver	0·17	0·226
Sulphur	12·33	2·324
Copper and Antimony Sulphides	1·24	
Iron and Zinc	0·96	
Gangue	4·93	2·85
Moisture, loss, &c.	0·69	
	100·	

"The silver in A—60·92 oz. per ton of galena or 76·34 oz. per ton of lead.

"The silver in B—60·92 oz. per ton of galena or 101·9 oz. per ton of lead.

"A sample recently assayed by Mr. Mallet contained 99 oz. of silver to the ton of lead.

"*Hazaribagh District: Mahabank or Mahabagh*, Lat. 24° 25'; Long. 86° 25'—On the Putro river, about 1 mile north-north-west of the village of Mahabank, and about the same distance to the north-north-east of Gulgo, in the Pachamba Sub-Division of Hazaribagh, Mr. Mallet describes the following section :—

'(*a*) Hornblende schist overlaid by—

'(*b*) Largely crystalline white limestone containing scales of light green mica here and there; this bed is about 6 feet thick and is covered by—

'(*c*) A peculiar mixture of garnet and coccolite, containing traces of galena and copper. In places the two minerals are well intermixed; in others the garnet occurs in a pure massive form (so called calderite) only a few feet of this rock (*c*) is seen.

'Specks of copper pyrites and zinc blende were observed in the last named rock, and on the north bank of the river the beds are cut through

by a nearly vertical granite vein which contained galena. The limestone appeared to be in useful quantity.'

"During the past year (1880) this deposit was opened out and some very fine specimens of argentiferous galena with copper pyrites and zinc blende were obtained. A Company was formed in Bombay, bearing the title 'Imperial Silver Lead Mining Company, Limited,' with a capital of Rs. 6,00,000, having for its declared object the development of these ores.

"Owing to the promoters having absconded and other circumstances of too recent and current a nature to be treated here as matter suitable for historical comment, the Company's operations have been in abeyance, and there is no further information available as to the extent of the deposit.

"*Baragunda*, Lat. 24° 4′ 3″; Long. 86° 7′.—In the course of some recent excavations which have been made at the copper mines at this locality galena has been obtained.

"*Mehandadi*, Lat. 24° 22′ 30′; Long. 86° 20′.—Loose fragments of lead ore (cerussite) were obtained on the surface, a short distance to the east of Mehandadi. According to Mr. Mallet the nature of the source from whence they were derived is not known, as grounds had not been broken. Mehandadi is about 6 miles to south-west of Mahabagh.

"*Barhamasia*, Lat 24° 20′; Long, 86° 18′.—Similar fragments are alluded to by Mr. Mallet as having been found at Barhamasia, about 3½ miles south-south-east of Mehandadi. A specimen of cerussite, forwarded by Mr. G. Peppe from this locality, yielded on assay by Mr. Tween 86·52 per cent. of lead, but no silver.

"*Nyatand*, Lat. 24° 30′; Long. 85° 45′.—Under the name Lat, Captain Sherwill in his Geological Map of Bengal indicates a lead mine which was probably in the vicinity of the village of Nyatand. The name Lat, is not to be found on modern maps. No particulars appear to have been placed on record in reference to this mine.

"*Khesmi*, Lat. 24° 25′; Long. 84° 45′ 50″.—Similar fragments to those at Barhamasia were found here and at—

"*Nawada*, Lat. 24° 25′ 25″; Long. 84° 45′ 12."

"*Mukundganj*, Lat. 23°57′; Long. 85°25′ 30."—There are two references to the existence of a lead mine in a hill close to a village with the above

name, which is situated about 3 miles south of the cantonments of Hazaribagh. The first is by Surgeon P. Breton, and the second is in a letter addressed to the Coal Committee by Surgeon Drummond. The exact position of this mine, if it ever existed, appears to have been forgotten.

"*Parseya*, Lat. 24° 10'; Long. 85° 51'.—During the past year some large rolled masses of vein stuff with lead ore, principally galena, were during the rains washed out of the alluvium on the bank of the river near Parseya. Mr. Hewitt, Commissioner of Chutia Nagpur, who has kindly supplied information upon this and several other mineral deposits in his Division, states that these masses of ore had much the appearance of being only the residuum of an original vein or pocket, the matrix of which had been washed away. No trace of the ore *in situ* could be found.

"*Hisatu*, Lat. 23° 59' 30"; Long. 85° 3' 30".—The lead ore of this locality is first mentioned in a letter from Messrs. Molte and Farquhar, addressed to Warren Hastings and the Council, dated Calcutta, 1777. The ore they state had been analysed, and that it consisted of lead and not of antimony. They applied for permission to work it, and at the same time certain iron mines as will elsewhere be described in this volume (Chap. VIII.)

"LOHARDAGGA DISTRICT: *Barikhap*, Lat. 24° 20' 30"; Long. 85° 15" 20'.—Close to a village of the above name, which is about 3 miles north of Balumath, rolled fragments of galena, partly converted into cerussite, have been obtained. The rocks of the vicinity belong to the metamorphic series.

"*Sili*, Lat. 23° 22" 30'; Long. 85° 54'.—Specimens similar to the above were obtained by Mr. F. Linde close to Sili, on the Subanarekha, samples of which are now in the Geological Museum, but no further particulars have as yet been ascertained.

"SIRGUJAH STATE: *Bhelounda*, Lat. 23° 52' 30"; Long. 83° 18' 30".—Specimens of galena from a hill called Puttia, near the village of Pelowa, in the Ramkola zemindary, were forwarded to the Government in the year 1865 by Colonel Dalton, in order that an assay might be made. From the original manuscript it appears that this locality, which was

only known from native report, was situated about 24 miles north of Pertabpur, so that it corresponds with Bhelounda of the maps, which is, however, not in Ramkola but in Pal, an adjoining tuppeh. The rocks of this neighbourhood are similar granitic gneisses to those at Chiraikund, and they lie on about the same east and west strike.

"The specimens of galena forwarded by Colonel Dalton yielded a trace of silver. The clean ore, it was stated, would be worth from £12 to £13 per ton. An attempt to work the mine, by whom it is not stated, proving unprofitable, it was abandoned.

"*Chiraikand*, Lat. 23° 53′; Long. 82° 52′.—About 1¼ mile to the south-west of the village of Chiraikund, in the Ramkola zemindary, district of Sirgujah, and not far from the south-west boundary of Mirzapur, there is an abandoned lead mine which was formerly worked by a Mr. Burke.

"Mr. Mallet describes the ore as apparently occurring in two pockets in a light grey horny quartzite which runs parallel to the surrounding gneiss. Sparsely disseminated galena was found in the quartzite, but there were no indications of the existence of a true lode. Small crystals of cerussite were observed, but there were no traces of antimony."

1881. Mallet. Lead, &c., Dhadka.

The following report on the metalliferous indications in the neighbourhood of Dhadka was made by Mr. Mallet, then of the Geological Survey of India, for Messrs. Schœne, Kilburn & Co. of Calcutta.

"I have examined some of both of the localities in the neighbourhood of Dhadka, Manbhoom, where indications of metalliferous deposit have been observed, and I have now the honor to submit the following report thereon:—

"It is unnecessary for me to make any remarks on the general geology of the country, as this has already been described by Mr. Ball in his official report on the District of Manbhoom and Singbhoom, and in his report to your firm on the occurrence of argentiferous galena and gold in the neighbourhood of Dhadka; the rocks all belong to the submetamorphic or transition series.

"*Jani Juri.*—The argentiferous galena just mentioned, which was discovered by Mr. Ball in 1869 is the deposit which has been longest known, and to which most attention has been directed. The richness of some specimens of the ore obtained, and the very large proportion of silver contained in it, amounting to 100 ounces or more per ton of lead, naturally attracted considerable interest towards the locality; these promising indications, however, have not been substantiated by anything which I have seen myself.

"The exposed outcrop of the vein, from which I was told the galena had been obtained, is situated about half way up the southern slope of the hill 1¼ mile E. 35 N. from the village of Diga (Dekia of map) and less than ½ mile N. of the Jani Juri; according to the map this position is ¾ mile E. of Dhadka. Mr. Ball stated that the lead is rather more than a mile E. of the same place. I am of opinion that the map can be implicitly relied upon, the rock in which the vein occurs is gray clay-slate verging towards mica schist which dips at the spot where the ore is said to have been originally found, about S. 30° W. at 30°-40, the strike therefore being parallel to the direction of the hills; *in the weathered* surface the rock is red from peroxidation of the ore; the vein throughout the portion visible at present runs, approximately at least, if not quite parallel to the foliation of the schist, (Mr. Ball states that "the ore occurs quite independently of the bedding of the schists," a discrepancy from my observations which is possibly due to the section not having been as well exposed when Mr. Ball saw it as when I did). Mr. Deveria informed me that where thickest it was about 14 inches across, the sides being of rusty, partly crystalline quartz, while the central portion was partly empty and partly filled by loose lumps of galena. Their looseness would doubtless be caused by the removal, through natural causes, of some other material which originally filled the vacant spaces,—this galena-bearing portion of the vein had, I was informed, been worked out before my arrival, and only a few feet from the spot pointed out as the richest,—the vein was (as I saw myself) only two inches thick, consisting of gossany crystalline quartz with well-marked walls, and an irregular cellular space towards the middle. No galena was contained here either in the quartz, or in the central cavity. A shallow trench has been dug along the apparent course of the vein for some 20 or 25 yards, but except towards the centre, the

surface débris was not fully cleared away at the time of my visit, so that I only saw the vein at the spot first alluded to.

"130 feet to E. 30° S. of the above-mentioned excavation, Mr. Deveria has made a second, and caught the vein again there. It varies from 1 to 4 or 5 inches in thickness in as many feet, and does not exceed 5 inches across where exposed. Here, as in the first-named locality, it is parallel, or nearly so, with the foliation of the schist, which dips S. 30° W. at 40°. The vein is of quartz, with more or less ochreous or gossany limonite (brown iron ore) and occasional spots of cervantite (antimony oxide). I observed no galena, but Mr. Deveria informed me that he had obtained a little previously.

"The fact that other quartz veins in the immediate vicinity run obliquely to the foliation of the schist, coupled with the 'ribboned' structure of the vein in question, *points to its being a true vein*, not a bed in the schist, notwithstanding the fact that it was parallel to the foliation of the latter.

"It would appear then from the information afforded me by Mr. Deveria, that practically all the galena hitherto obtained (the amount of which I have been unable to ascertain clearly) has been extracted from a portion of the vein which did not exceed a very few yards in length, with a maximum thickness of 14 inches. In this spot there was, as it would seem, a considerable proportion of ore. A few feet below, however, the vein is contracted to 2 inches in thickness, and contains no galena, and 130 feet to E. 30° S. it is 1 to 5 inches thick with but little lead ore (none that I saw). Arguing then from the above data (what I was told and what I saw), it would appear that at the spot where the ore was originally found, there was a pocket, or local accumulation of ore and thickening of the vein. In this case, other pockets may perhaps be found by tracing the vein along the outcrop, or the vein may possibly be found to increase in thickness in one, or even in both directions. These are points, however, on which no definite opinion can be given. They can only be tested by actual trial. I think therefore that attention should at present be directed to tracing the outcrop of the vein in both directions as far as possible. This might be done either by a continuous trench along the course of the vein, or by a series of cross trenches at short intervals. The former method would

have the advantage that no pockets could be overlooked, as they might be if they happened to be between the cross trenches. But the vein, if shifted by any faults, would have to be looked for where lost by a cross trench.

"There is further the possibility that the gossany brown iron ore, which occurs in considerable quantity in some parts of the vein, may be due to the decomposition of some other ore, most probably copper or iron pyrites. To test this point it would be necessary to penetrate to the unaltered portion of the vein, which would perhaps be reached at 30 feet or less from the surface, but possibly not under 50 or 70. As further on I recommend a trial of this kind to be made at Sidatal, the results there, as well as the results obtained in tracing the Jani Juri vein along the outcrop, might perhaps be waited for before sinking a shaft at Jani Juri.

"A sample of the gossany brown iron ore (taken from the bags sent to Calcutta by Mr. Deveria) yielded one ounce of silver to the ton with very distinct traces of gold.

"The exposed outcrop of the Sidatal (Seedaal) vein is about 300 yards N. 30° W. from the village, at a height of about 30 feet from the base of the hill, past which a small rivulet runs (containing a little water in the early part of December). The country rock is greenish gray micaceous schist, with irregular dip to E. and W. of N. at about 20°. By means of a trench cut down through the surface debris, Mr. Deveria has laid the outcrops of the vein bare for a length of about 30 feet; the vein strikes N. 15 W. and is nearly vertical (80° to E. 15 N.) throughout the greater portion of the part seen, but at the southern end dips at a lower angle. It has been dislocated by two or three small slips of a foot or two. As will be seen from the dips and strikes given above, it distinctly cuts across the foliation of the schist. The vein varies in thickness from 5 to 8 inches, and is chiefly composed of gray and white non-cellular quartz, but there is a considerable proportion of ochreous or gossany oxide of iron also. The latter is mostly brown (hydrous), but partly red (anhydrous) oxide. There are also, here and there, spots of copper pyrites, the largest I saw being about the size of a two-anna piece; also brown blende (zinc ore) in about equal quantity; specks are also visible of iron pyrites, cobaltite, malachite, siderite, and ruby copper. I observed no galena or calvantile.

"A couple of feet to the W. of the above vein, and paralled to it, there is a smaller one, varying from 1 to 5 inches in thickness, of similar character as to gangue and ores, except that the latter are in smaller proportion.

"The best way to test the Sidatal vein would, in my opinion, be to sink a vertical shaft at the bottom of the present trench to a depth of, say, 30 feet, and then to drive in horizontally at right angles to the strike of the vein, in order to see whether the ochreous oxide of iron changes below into a more valuable ore. If at the depth mentioned, oxide of a character similar to that at the surface should still be found, it would be necessary to sink deeper. The slope of the hill is too gradual, and the elevation of the outcrop above the stream previously mentioned is too small, to admit of an adit being advantageously driven. The oxide may perhaps be found to change beneath merely into a somewhat more compact form of iron ore, perhaps into hæmatite or magnetite; but even if it should be proved to result from the decomposition of copper pyrites, the vein, unless thicker than at the exposed outcrop, could scarcely be regarded as more than moderately rich, for although in some spots it is mainly composed of iron oxides, still the great mass of it is quartz.

"If while the shaft was being sunk the vein were also traced along its outcrop, it would, of course, be an advantage, but the shaft is the important point at present, for unless the gossany iron oxide changes into more valuable ore, the vein (judging from what is now visible) would be quite worthless.

"A sample of the gossany oxide yielded on assay 17 dwts. of silver to the ton with traces of gold.

"A few yards lower down the hill Mr. Deveria had made another opening, and obtained some fragments of ore (blende?), but these were embedded in loose debris, and had very probably come from the vein just described.

"Less than ½ mile S. of Jamnagora (Choonagora of map) the outcrop has been very imperfectly exposed for a quartz vein penetrating semi-decomposed clay-slate. Judging from the pieces extracted, the vein would seem to be about 10 inches thick. It is of grayish-white noncellular vitreous quartz, containing gossany brown iron ore; the proportion of the latter is small in the greater part of the quartz which has been

extracted, but here and there it occurs in larger amount. Spots of galena occur very sparingly, and specks of blende are also occasionally to be seen. Mr. Deveria informed me that he had obtained some larger pieces of galena previously from the loose debris at the spot. From fragments of veinstone scattered on the surface, I was led to think that the vein most probably strikes about W. 30° N.

"About ½ mile N. of the above-mentioned locality, near the village of Jamnagora, pieces of quartz, with brown, and a little red, gossany oxide of iron were pointed out to me lying loose on the surface of a field. Mr. Deveria informed me he had been told by a native that some galena had been found here, but we obtained none when visiting the spot.

"In the hills ½ mile or more N. of Párgora pieces of quartz with iron oxide of the usual character, and containing specks of cervantite and blende, have been found in the surface debris but no solid rock was exposed in the hole I saw.

"A few hundred yards to the N. E. of Díga (Dekia) some pieces of brown iron ore containing occasional spots of cervantite are scattered loose on the surface. Cervantite accompanies the lead ore at the Jani Juri vein, and probably indicates the existence of galena here also. But the fragments being loose, there is no clue to the exact position of the vein.

"The only means of testing the last mentioned localities would be by one or more trenches cut through the surface debris down to the rock *in situ*, where the fragments occur, and for some distance on either side of them, the best direction for the first trench would probably be N. E.—S. W. (*i.e.*, across the known direction of the Jani Juri and Sidatal veins). If this failed, a second might be tried at right angles to it. If the deposit, however, should not be a continuous vein, but a pocket only, both the above-mentioned trenches might, and not improbably would miss it. A series of parallel trenches at short intervals would be necessary, but the results likely to be obtained would scarcely justify the expense of digging such.

"Galena is said to have been obtained at Chila also, but owing to a change of arrangements I was unable to visit the place.

"I observed vein quartz with gossany iron ore lying loose on the surface in several places that I have not noted.

"To sum the matter up then, there are in several places evidences of the existence of various metals, notably lead, silver and copper, and it may be that these exist in workable quantity. But I have myself seen no evidence whatever *proving* that they do. The only localities where the veins were sufficiently exposed for me to form any opinion about them were at Sidatal and Jani Juri. It will have been seen that my opinion about the latter, formed from the information given me by Mr. Deveria, combined with what I saw myself, is not very favourable to the value of the Sidatal vein (in as far as can be judged from what is now visible) which rests wholly on whether the gossany iron oxide is an indication of more valuable ore beneath. It may be, as I have previously said, merely an ore of iron altered near the surface, but should it be found to change at Sidatal into valuable mineral, a similar change would probably be found to occur in other places also. The putting this question to the proof is therefore an important point at present."

The complete evidence, as obtained by previous explorers regarding the copper and lead ores is now before the reader; and it is strongly in favour of a presumable workable development in many places, though at the same time it exhibits the same essentially uncertain occurrence of these ores which is so common in all metalliferous countries. We cannot put forward more hopeful promise than that given by such a very able exploiter as M. Stoehr; or by such well qualified geological explorers as Mallet and Ball: but it would, we think, be a very exceptional and strange condition of mineral occurrence should the whole of this great metalliferous tract in the Peninsula turn out eventually to be devoid of any particularly strong and continued occurrence of one or other of these ores.

The occurrence of the baser ores, as contrasted with that of the gold, is not so markedly restricted to the areas of

transition rocks; for frequent instances are given of copper and lead mines having been worked in tracts which are manifestly in the crystalline area, though in many of these cases it is quite possible that there have been enfoldings, or faultings of the schistose series within the gneisses, of which only traces are now left in narrow strips.

The runs of fault-rock so often referred to in the first part of this book—also called quartz, quartz-rock, quartzites, breccias, granulits and felspathic rocks, by Stoehr and others—are in many cases the holders of lead and copper ores: and these are often prolonged right into the crystalline or gneissic area north of the great belt of schistose rocks; and in such a position, when they contain these ores, the ores would be considered as in the gneissic area.

It cannot, however, be said that occurrences of these ores in the crystalline region are, or are not, likely to be rich; though some of them give evidence of fair promise: the data, so far, tend to show that they are very local and not, likely to last through any length or depth in their matrix. In fact, there seems more likelihood of the ore occurring in pockets rather than in lodes.

On the other hand, the more frequent development of these ores in the transition region is certain; so that, howsoever mining development shall progress, it must ultimately be concentrated in the transition areas, or such outliers of them as are known, or may hereafter be found distributed over the northern and western portions of the Province.

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